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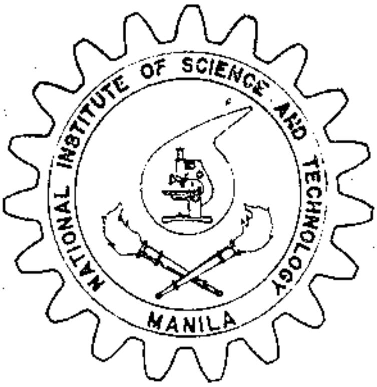
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A SURVEY OF PHILIPPINE SOILS FOR ANTIBIOTIC-PRODUCING STREPTOMYCES*

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TWO PLATES

Microorganisms are the primary producers of antibiotics. The spore-forming bacteria, the fungi(4) and the actinomycetes(2) are considered potential producers of antimicrobial substances. Florey, et al.(8) cited Fleming for discovering in 1929 certain cultures of *Penicillium notatum* Westling which possess antibacterial properties. He also mentioned that Chain and co-workers, working at Oxford in 1940, produced a dry stable extract of penicillin from culture broths by using the strain of *Penicillium* studied by Fleming. He further stated that in 1932 Dubos found that certain spore-forming bacteria produced enzymes that hydrolyzed the capsular material of pneumococcus. From the soil, in 1939, the latter also isolated *Bacillus brevis* Migula *emend.* Ford which destroyed gram-positive bacteria.

Although the bacteria yielded a number of important antibiotics like bacitracin, and polymyxin and the molds gave penicillin, clavacin and many others, the actinomycetes have contributed the greatest number of antibiotic producers(2) among which are streptomycin, neomycin, oxy- and chlortetracycline,

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* This study was undertaken at the Bureau of Research and Laboratories, Department of Health, Manila with the financial support from the National Science Development Board, Manila.

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chloromycetin and many others. A systematic screening of the latter organisms for their antibiotic potentials gave a high degree of success. Surveys made by several research teams in the United States and other foreign countries, showed that antagonistic streptomyces are widely distributed in nature especially in soils and composts. This group is still leading all other groups of microorganisms in the research field as potential producers of new antibiotics possessing antibacterial, antifungal, antiviral and even antitumor properties.

The antibiotic properties of actinomycetes have been thoroughly presented and discussed by Waksman(17, 18) in 1946 and 1947 and by Benedict(2) in 1953. In his study of 244 cultures isolated from different soils, Waksman(15) found that 20 per cent possessed high antagonistic properties and 43.4 per cent showed some antagonistic activities. Emerson, et al.(7) found that 52 per cent of the actinomycetes they isolated showed some inhibitory activity against at least one of the five test bacteria and 46 per cent were active against at least one of the six pathogenic fungi. Schatz and Hazen(13) similarly observed that out of 243 actinomycetes isolated from soil and compost materials, 51 per cent were antagonistic to one or more of the four test fungi. In 1956 Chua(6) made a survey of the antibiotic-producing streptomyces in the southwestern area of the Republic of Korea and reported that 55 per cent showed antibiotic activity against either *Micrococcus pyogenes* var. *aureus* or *Escherichia coli* or both.

There is a world-wide search for potential antibiotic producers today. In Northern Canada Landerkin, et al.(10) observed that 61.2 per cent of the 660 cultures of actinomycetes that they isolated showed antagonism to at least one of the eight test organisms. It is also noteworthy to mention that McGuire, et al.(11) reported an actinomycete *Streptomyces erythreus* isolated from a Philippine soil sample which produced an antibiotic of broad spectrum activity labelled as "Ilotycin." Also isolated from a sample of Philippine soil is an actinomycete *Streptomyces filipinensis.* The isolation and properties of the antifungal antibiotic Filipin produced by this streptomyces was reported by Whitfield, et al.(19) in 1955.

In 1952, Celino and co-workers(5) reported that some of the microbes isolated from Philippine soils were found in preliminary screening tests to be strongly antagonistic to other microorganisms. Some of their promising antagonists were demonstrated to check the growth of *Mycobacterium tuberculosis* 607 and *Staphylococcus aureus* in *vitro*.

The history of the discovery of streptomycin has been dramatized by Waksman(14) who stated that 10,000 cultures had to be isolated and tested before streptomycin was found. He further narrated that in view of the rapidly increasing number of available antibiotics, this number would be multiplied by 10 before another substance possessing new chemotherapeutic potentialities is found.

However, it is worthy to mention the fact that a chance discovery may yield a good antibiotic producer as was shown by Fleming in his announcement in 1929 of a species of *Penicillium* later identified as *P. notatum*, which was a contaminant of a plate culture and which gave the world the first commercial antibiotic commonly known as penicillin.

Since several workers found the streptomyces to be good antibiotic producers our study was focused on this group of microorganisms as potential new sources of antibiotics. It is felt that there is still a need for antibiotics in the treatment of infectious diseases.(12) The increased resistance of some disease-producing microorganisms to certain antibiotics pose as a new challenge to workers in this field to continue their search in the hope that they will find new antibiotics with steadfast antagonistic property.

This paper deals with the isolation and selection of strains of microorganisms, particularly of the actinomycetes, that are promising antibiotic producers. It also covers a preliminary evaluation of their antibiotic activities.

MATERIALS AND METHODS

Source of sample.—Soil samples were gathered from various localities in the Philippines. Composts in Manila and suburbs were additional sources of the streptomycetes.

Media.—Asparagine agar (asparagine 0.85 gm, monobasic potassium phosphate 1.0 gm, glycerine 10 ml, agar 20 gm, and distilled water 1,000 ml) was used for the isolation of the streptomyces strains. Emerson agar (Bacto-peptone 4 gm, beef extract 4 gm, sodium chloride 2.5 gm, dextrose 10.0 gm, yeast extract 1.0 gm, and distilled water 1,000 ml) pH 6.7 was employed for testing the antibiotic activity of the cultures against baceria and fungi. For testing against *Mycobacterium tuberculosis* 607, malachite green agar (glycerine 10 ml, beef extract 4 gm, peptone 4 gm, yeast extract 1.0 gm, sodium chloride 2.5 gm, malachite green (0.5 per cent) 1.5 ml, agar 20 gm, and distilled water 1,000 ml) adjusted to pH 7.0 was used.

Test organisms[2].—The test organisms used in this study are the following: *Micrococcus pyogenes aureus* 209 P, *Bacillus subtilis* FDA 219, *Escherichia coli,** *Salmonella gallinarum* (Copenhagen strain), *Pseudomonas aeruginosa,** *Alcaligenes faecalis,** *Paracolon aerogenic,** *Mycobacterium tuberculosis* 607, *Saccharomyces cerevisiae,** *Candida albicans.**

Method of isolation.—One gram of soil or compost was suspended in 50 ml of sterile tap water in a small flask. This was then shaken vigorously for about five minutes. Dilutions of 1 : 500, 1 : 1000, 1 : 5000, 1 : 10,000, 1 : 50,000, 1 : 100,000 and 1 : 500,000 were made. One ml of each of the dilutions was plated out with ten ml of asparagine agar. The plates were left at room temperature for five days to one week. Characteristic streptomyces colonies as described in Bergey's Manual of Determinative Bacteriology(3) were selected and transplanted into Emerson agar slants.

Testing of antibiotic activity.—The antibiotic activities of the streptomycetes were tested by: (*a*) cross-streak method(8) and (*b*) the modified agar-plaque method or plug-test procedure of Harris and Ruger.(9)

Cross streak method: A streak of the isolate is made across an Emerson agar plate and incubated at room temperature for 5 to 7 days or until the organism has grown and sporulated abundantly. The test organisms are then streaked at right angles to the first streak and the plate is incubated at 37°C for 18 to 24 hours. The antibiotic activity is determined by measuring the inhibition in millimeters of the growth of the test organisms from the primary streak.

Plug-test procedure or agar-plaque method: The isolates were streaked on Emerson agar slants. After about five days at room temperature, when sporulation was abundant, the growth was smeared heavily into Emerson agar plates in quadrants (four isolates on one Petri dish). These were incubated at room temperature until maximum growth and sporulation were observed. A sterile cork borer, 7.5 mm in diameter, was bored through both the surface growth of the organism and the layer of Emerson agar. The plugs thus prepared were carefully placed on the surface of assay plates previously seeded with the test organisms as described below. The plates were refrigerated for at least one hour before incubation. After 18 to 24 hours incubation at 37°C, the antibiotic activity was determined by measuring the zone of clearing or inhibition on the assay plates around each agar plug.

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[2] The microorganisms with asterisk (*) after their names were furnished by Dr. Santiago Montemayor, chief bacteriologist, Bureau of Research and Laboratories, Department of Health, Manila.

Preparation of assay plates.—The test organisms were first inoculated in Emerson broth, placed in a shaker and were allowed to remain shaking for 24 hours at room temperature. The procedure was slightly modified for *M. tuberculosis* 607, which was inoculated in malachite green broth instead of in Emerson broth and was shaken for 48 hours.

A base layer was prepared by pouring 17 ml of melted Emerson Agar into sterile Petri dishes and allowing the agar to solidify. Over the solidified base layer, 3.5 ml of a one per cent bacterial suspension in melted Emerson agar at 41°C was seeded. For *M. tuberculosis* 607, malachite green agar was used.

RESULTS AND DISCUSSION

The results of the screening of soil samples and composts for their antibiotic activities are shown in Table 1. Six of the isolates showing typical growth of streptomyces on agar slants are shown in Plate 1, fig. 1. Plate 1, fig. 2 shows a streptomyces isolate at the center streak and test organisms on the cross streak, five of which show growth inhibition.

Out of the 294 streptomyces cultures isolated from soils and composts and tested for their antibiotic activity, 80 cultures or 27.2 per cent were found to be antibiotic producers of varying capacity. When tested against ten test organisms consisting of two gram-positive, five gram-negative and one acid-fast bacteria and two yeasts, the isolates were found to inhibit at least one of the test organisms but only two cultures inhibited all of them. It may be seen in Table 2 that, so far, the soil samples came only from 13 places; and out of the 30 soil samples examined, 80 cultures were found active antibiotically. These cultures, when tested against the ten test organisms, showed varying spectra of inhibition as shown in Table 1.

TABLE 1.—*Streptomyces isolates and their antibiotic activity against 3 test bacteria and 2 test yeasts.*

Isolate number	Origin	Activity of cultures against									
		Micrococcus pyogenes aureus 209 P	*Bacillus subtilis* FDA 219	*Escherichia coli*	*Salmonella gallinarum*	*Pseudomonas æruginosa*	*Alcaligenes fæcalis*	*Paracolon ærogenic*	*Mycobacterium tuberculosis* 607	*Saccharomyces cerevisiæ*	*Candida albicans*
5778	Batangas 4	†††	†††	††	††	†	††	†	††	†††	††
5779	Batangas 2	††††	†††	†††	††	††	††	††	†††	††††	††††
5579	Alabang, Rizal	†††	†††	†††	††††	†††	†	†††	††	†	†
5777	Batangas 4	††	††††	††	†	†	††	†	*	†	†
567	Diliman, Quezon City	*	†	†	†	††	†††	†	†	†††	†
5719	Quezon City	†††	†††	††	††	*	†††	†	†††	††	††
5746 B	Bankerohan Altavas Aklan	†	††	†	†	*	*	†	†	†	†
582	Diliman, Quezon City	†	††	*	*	††	††	†	†	††	††
5782	Agusan 2	†	††	*	*	*	††	†	†	††	†
5742 B	Dao, Highway, Sta. Cruz, Dumalog	*	†	†	†	*	††	†	*	†	††
5751	Compost, SLH	†††	††††	*	††	†	†††	††	*	††††	*
5797	Compost, SLH	††	*	†	*	†	†	††	†	†††	*
5788	Batangas 4	††	†	*	*	††	††	*	†	††	†
5785	Batangas 4	††	††	†	*	*	*	†	††	††	††
5739	Sulu S-611	††	††	†	*	*	†	†	†††	†	*
5725	Batangas 3	†††	†	*	*	†	†	†	†	†	†
5722	Batangas 3	†	*	††	*	†	†††	†	*	†	†
5618	Papaya, Nueva Ecija	†††	††	†	*	*	†	*	†	†††	††
57107	Manhoy, Dao, Capiz	††	†	*	*	†	†	†	†	*	†
5727	Batangas 1	††	††	††	†	*	*	*	†	†	†
5731	Batangas 3	††††	††††	*	*	*	†	*	†††	†	†
5615	Peñaranda, N. Ecija	††	†	††	*	*	*	†	††	†	*
5753	Compost, SLH	†††	††	*	*	†	*	†	*	†††	††
57101	Batangas 4	†	††	††	*	*	*	*	†	†††	††
57102	Batangas 4	††	††	*	*	††	*	*	††	†††	††
5781	Batangas 4	*	†	*	*	†	†	†	†	†	*
5792	Batangas 4	††	†	*	*	††	*	*	††	†††	††
5780	Sulu 1	†††	†††	*	*	*	*	†	†††	††	††
5730	Agusan 1	†	††	*	*	†	*	*	††	††	*
5787	Batangas 4	††††	†††	*	*	*	*	†	†	††	†
5721	Quezon City	†	*	*	*	†	†††	†	*	††	††
5618 A	Papaya, Nueva Ecija	†††	†††	†	*	*	*	*	†	†††	††
5724	Batangas 4	††††	†††	††	††	*	†	*	*	*	*
5610	Peñaranda, N. Ecija	†††	†	*	*	*	*	†	*	†	†
5749	Balete, Aklan	*	*	†	*	*	†	†	†	††††	*
57110	Ibajay, Aklan	††	††	*	*	*	*	†	†	††	††
57108	Balete, Aklan	†††	†	††	*	*	†	†	*	*	*
5744 A	Sigma, Capiz	††	†	†	*	†	*	*	*	*	†
5733	Batangas 5	*	*	*	*	†	†	*	*	†	†
5732	Batangas 5	*	††	*	*	*	*	†	*	†	††
5789	Compost, SLH	*	*	*	*	†	*	†	*	†	†
57104	Barotac Viejo, Iloilo	*	*	†	*	*	*	†	†	†	*
5746	Balete, Aklan	†††	†	*	*	†	*	†	*	*	*
5794	Compost, SLH	††	*	*	*	†	†	†††	*	*	*
5799	Compost, SLH	††	†	*	*	*	††	*	*	††	*
5734	Batangas 5	*	*	*	*	*	†††	†	*	††	†
5783	Batangas 4	*	††	*	*	*	††	††	†	*	*
5612	Peñaranda, N. Ecija	††	††	*	*	*	*	†	†	*	*
5616	Papaya, Nueva Ecija	†	*	*	*	*	*	†	†††	†	†
5740	Batangas 58	††	††	*	*	*	*	*	*	††	††
5617	Papaya, Nueva Ecija	†	††	*	*	*	*	†	*	†	*
5786	Batangas 4	†	†	*	*	*	††	*	†	*	*
5784	Batangas 4	†	†	*	*	*	††	*	†	*	*
57106	Dao, Capiz	†	*	*	*	†	†	*	*	*	†

Legend: ††††, inhibition of 30 mm and above; †††, inhibition of 15 to 29 mm; ††, inhibition of 5 to 14 mm; †, inhibition of less than 5 mm; *, negative inhibition.

5736	Sulu S-611	*	*	*	*	*	*	†	*	†	†
5795	Compost, SLH	††	*	*	*	*	*	*	*	†	†
562	Diliman, Quezon City	*	*	*	*	*	†	†	*	††††	*
563	Diliman, Quezon City	††††	†††	*	*	*	*	†	*	*	*
5796	Compost, SLH	†	*	*	*	*	*	†	*	†	*
5742 A	Dao, Highway, Sta. Cruz, Dumalog	*	*	†	*	*	†	†	*	*	*
5614	Peñaranda, N. Ecija	†††	††††	*	*	*	*	*	†††	*	*
5744 B	Sigma, Capiz	†††	*	*	*	*	*	*	*	†††	††
5775	Compost, SLH	†	*	†	*	†	*	*	*	†	*
5793	Batangas 4	†	†	*	*	*	*	†	*	*	*
5776	Compost, SLH	*	*	*	*	††	††	†	*	†	*
5790	Batangas 4	*	††	*	†	*	*	*	*	†	*
5735	Batangas 5	*	*	*	*	†	*	*	*	††	*
5747	Balete, Aklan	†	*	*	*	*	*	*	*	†	*
5729	Agusan 1	†	†	*	*	*	*	*	*	*	*
5798	Compost, SLH	*	†	*	*	*	*	*	*	†	*
5745	Altavas, Aklan	*	*	*	*	†	*	*	*	*	*
5748	Lalab, Balete, Aklan	*	*	*	*	†	*	*	*	*	*
565	Diliman, Quezon City	*	*	*	*	*	*	*	*	†	*
57100	Compost, SLH	†	*	*	*	*	*	*	*	*	*
574	Nueva Ecija	*	*	*	*	*	*	*	*	*	†††
579	Diliman, Quezon City	*	*	*	*	*	*	*	*	†	*
5611	Peñaranda, N. Ecija	*	†	*	*	*	*	*	*	*	*
5728	Batangas	*	*	*	*	*	*	*	†	*	*

Legend: ††††, inhibition of 30 mm and above; †††, inhibition of 15 to 29 mm; ††, inhibition of 5 to 14 mm; †, inhibition of less than 5 mm; *, negative inhibition.

TABLE 2.—*The numbers of antibiotically-active streptomyces isolated from soils of different sources.*

Origin of soil samples	No. of soil samples examined	Streptomyces cultures isolated	Active cultures observed	No. of cultures active against									
				Micrococcus pyogenes aureus 209 P	*Bacillus subtilis* FDA 219	*Escherichia coli*	*Salmonella gallinarum*	*Pseudomonas æruginosa*	*Alcaligenes fæcalis*	*Paracolon ærogenic*	*M. tuberculosis* 607	*Saccharomyces cerevisiæ*	*Candida albicans*
Agusan	2	10	3	3	3	—	—	1	1	—	2	2	2
Aklan	6	24	9	6	5	3	1	3	2	6	2	5	2
Alabang	1	12	1	1	1	1	1	1	—	1	1	1	1
Batangas	5	61	26	18	21	8	6	11	14	12	14	20	17
Capiz	3	19	4	4	3	1	—	3	2	1	1	1	4
Compost, S.L.H.	1	51	12	9	4	2	1	7	5	7	1	8	3
Dumalog	1	12	2	—	1	2	1	—	2	2	—	1	1
Iloilo	1	11	1	—	—	1	—	—	—	1	1	1	—
Legaspi	1	4	0	—	—	—	—	—	—	—	—	—	—
Marikina	1	4	0	—	—	—	—	—	—	—	—	—	—
Nueva Ecija	4	51	11	8	6	3	—	—	2	5	6	7	5
Quezon City	2	18	7	4	4	2	2	3	4	5	3	6	4
Sulu	2	17	4	2	3	1	—	—	1	6	2	4	2
TOTAL	30	294	80	55	51	24	12	29	33	46	33	56	41
Percentage of active cultures			27.2	68.7	63.7	30	15	36.2	41	57.5	41.0	70	51.2

TABLE 3.—*Numbers of active cultures grouped according to degrees of inhibition of test organisms.*

Test organisms	Total No. of active cultures	Degree of antibiotic activity							
		Very active		Moderately active		Slightly active		Very slightly active	
		No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
Micrococcus pyogenes aureus 209 P	55	5	9.1	14	25.5	17	30.9	19	34.5
Bacillus subtilis FDA 219	51	4	7.8	9	17.7	18	35.3	20	39.2
Escherichia coli	54	0	0	2	8.3	8	33.3	14	58.4
Salmonella gallinarum	12	1	8.3	0	0	5	41.7	6	50.0
Pseudomonas æruginosa	29	0	0	1	3.5	7	24.1	21	72.4
Alcaligenes fæcalis	33	1	3.0	5	15.2	12	36.3	15	45.5
Paracolon ærogenic	46	0	0	2	4.3	4	8.3	40	87.0
Mycobacterium tuberculosis 607	33	0	0	7	21.2	7	21.2	19	57.6
Saccharomyces cerevisiæ	56	4	7.1	10	17.9	14	25.0	28	50.0
Candida albicans	41	1	2.4	1	2.4	17	41.5	22	53.7

The predominant antibiotic spectra were against *M. pyogenes aureus* 209 P and *B. subtilis* FDA 219. This is shown by the number of cultures active against these test organisms numbering, respectively, 55 or 68.78 per cent and 51 or 63.7 per cent (Table 2). Table 3 shows that out of the 55 cultures active against *M. pyogenes aureus* 209 P, 5 are very active, 14 moderately active, 17 slightly active and 19 very slightly active. Likewise, out of the 51 cultures active against *B. subtilis* FDA 219, 4 are very active, 9 moderately active, 18 slightly active and 20 very slightly active. The active isolates within the above antibiotic spectra is 19.0 per cent, which is slightly higher than the findings of Landerkin, et al.(10) who obtained only 15 per cent.

Plate 2, fig. 1 shows the inhibitory zones of the isolates against *B. subtilis* FDA 219. It is also noticed that one of them belongs to the very active group, two to the moderately active, one to the slightly active, and 3 to the very slightly active.

The inhibitory action of the streptomyces isolates against *P. æruginosa,* which was shown in 29 out of 80 active cultures representing 36.2 per cent of all active isolates, appears very interesting for although this test organism has been reported by Emerson, et al.(7) as usually resistant to almost all antibiotic agents, it was found to be more sensitive than *E. coli* and *S. gallinarum,* as shown in Table 2. Although the inhibition was smaller in comparison to others, most of our streptomyces isolates were active against it. Plate 2, fig. 2 shows the inhibition of majority of the test plugs on a plate seeded with *P. æruginosa.* It will be noticed that the zones of inhibition are smaller than those in Plate 2, fig. 1. Our observation on the sensitivity of *P. æruginosa* to the action of antagonistic actinomycetes corroborates that of Waksman, et al.(17) for the same test organism.

Of the active cultures 57.5 per cent were found inhibitory against *Paracolon ærogenic,* a hemolytic strain of paracolon organism isolated in the Philippines (Table 2). This makes the isolated streptomyces cultures more interesting for, according to an observation of Dr. S. Montemayor of the Bureau of Research and Laboratories, *P. ærogenic* was found always closely associated with diarrhea enteritis among children at the San Lazaro Hospital in Manila. Even though the degree of inhibition was not so strong, still the high percentage of streptomyces isolates with inhibitory property makes it a worthwhile subject of further study. It is believed that in the future, studies with the object in view of increasing the antibiotic-producing potentials of the weak cultures would be worthwhile.

The antifungal properties of the isolates is evidenced by positive inhibitory action of many of them against the yeasts, *S. cerevisiæ* and *C. albicans.* Of the 80 streptomyces isolates found to possess the antibiotic property, those that were active against the two test yeasts were, respectively, 56 or 70 per cent and 41 or 51.2 per cent (Table 2). Out of the 56 cultures inhibiting *S. cerevisiæ,* only 7.1 per cent were very strongly inhibitory and 50 per cent were very slightly inhibitory (Table 3). Of the 41 cultures inhibiting *C. albicans,* 2.4 per cent were strongly inhibitory and 53.7 per cent were slightly inhibitory. At some future time, some of the isolates with pronounced antifungal property will be investigated for the possibility of producing antibiotics against fungi pathogenic to man. There are at present only a few of them in the therapeutic field.

Of the 33 cultures active against *M. tuberculosis* 607, 57.6 per cent showed very slight degree of inhibition (Table 3). Although not even one of them showed to be very strongly inhibitory there were seven which were moderately active and another seven which were slightly active.

In this survey of antibiotic-producing microorganisms in the Philippines, we found that 27.2 per cent of our isolated streptomyces possess varying antibiotic activities. Waksman(15) found 43.3 per cent of his isolates to be antagonistic. Emerson(7) found 52 per cent of his isolated actinomycetes to have some inhibitory activity and Chua(6) reported 35 per cent to be active against *M. pyogenes aureus* or *E. coli* or both. The percentage of active cultures that we obtained is less than what the above workers have reported. Accurate comparison is, however, not possible owing to the different test organisms and methods used in various surveys.

SUMMARY

Eighty out of 294 or 27.2 per cent of the *Streptomyces* strains isolated from soil and composts obtained from various places in the Philippines show antibiotic activity of varying degrees.

The predominant antibacterial spectrum of activity of the isolates was against *M. pyogenes aureus* 209 P and *B. subtilis* FDA 219.

The sensitivity of *P. æruginosa* to the action of the antagonistic streptomyces was quite remarkable. Although it was reported to be resistant to known antibiotics, it was found more sensitive than *E. coli* and *S. gallinarum* to the antagonistic action of local streptomyces.

Forty six or 57.5 per cent of the active cultures were found inhibitory to *P. ærogenic,* a hemolytic strain of paracolon isolated in the Philippines.

Fifty six or 70 per cent and 41 or 51.2 per cent of the active isolates were found inhibitory to *S. cerevisiæ* and *C. albicans* respectively.

Thirty three or 41 per cent were inhibitory to *M. tuberculosis* 607.

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REFERENCES

1. BARON, A. L. Handbook of Antibiotics. Reinhold Publishing Corporation, New York (1950) viii + 303 pp.
2. BENEDICT, R. G. Antibiotics produced by actinomycetes. Bot. Rev. (5) **19** (1953) 229-320.
3. BREED, R. S., E. G. D. MURRAY, and A. P. HITCHENS. Bergey's Manual of Determinative Bacteriology. The Williams and Wilkins Co., Baltimore, Md. (1948) xvi + 1529 pp.
4. BRIAN, P. W. Antibiotics produced by fungi. Bot. Rev. (6) **17** (1951) 357-430.
5. CELINO, M. S., S. V. JAVIER, and A. M. ACIERTO. An hitherto unexplored field of soil microbiology in the Philippines. Jour. Soil Sci. Soc. Phil. **4** (1952) 31–36.
6. CHUA, DOKI. Distribution of the antibiotic producing streptomyces in the Southwestern area of the Republic of Korea. Antib. Chemo. **6** (1956) 324–329.
7. EMERSON, R. L., A. J. WHIFFEN, N. BOHONOS, and C. DE BOER. Studies on the production of antibiotics by actinomyces and molds. Jour. Bact. **52** (1946) 357–366.
8. FLOREY, H. L., E. CHAIN, N. G. HEATLY, M. A. JENNINGS, A. G. SANDERS, E. B. ABRAHAM, M. E. FLOREY. Antibiotics (1949). Oxford Univ. Press, London **1–2** (1949) xv + 1774 pp.
9. HARRIS, D. A., and M. L. RUGER. Microbiological aspects of new antibiotic screening. Antib. Chemo. **3** (1953) 265.
10. LANDERKIN, G. B., J. R. G. SMITH, and A. G. LOCKHEAD. A study of the antibiotic activity of actinomycetes from soils of Northern Canada. Canadian Jour. Res. § C **28** (1950) 690–698.
11. MCGUIRE, J. M., R. L. BUNCH, R. C. ANDERSON, H. E. BOAS, E. H. FLYNN, H. M. POWELL, J. W. SMITH. 'Ilotycin,' a new antibiotic. Antib. Chemo. **2** (1952) 281.
12. RAPER, K. B., and R. G. BENEDICT. The drugs of microbial origin. The Yearbook of Agriculture U.S.D.A. (1950–1951) 734–741.
13. SCHATZ, A., and E. L. HAZEN. The distribution of soil microorganisms antagonistic to fungi pathogenic for men. Mycologia **40** (1948) 461–477.
14. WAKSMAN, S. A. The actinomycetes and their antibiotics. Nieuwland Lectures, Univ. of Notre Dame, Notre Dame, Indiana **6** (1952) 24.

15. WAKSMAN, S. A., E. S. HORNING, M. WELSCH, and H. B. WOODRUFF. Distribution of antagonistic actinomycetes in nature. Soil Sci. **54** (1942) 281–296.

16. WAKSMAN, S. A. The actinomycetes. Chronica Botanica Cp., Waltham, Mass. (1950) xvii + 230 pp.

17. WAKSMAN, S. A., A. SCHATZ and D. M. REYNOLDS. Production of antibiotic substances by actinomycetes. Ann. N.Y. Acad. Sci. **48** (1946) 73–85.

18. WAKSMAN, S. A. Microbial antagonisms and antibiotic substances. The Commonwealth Fund, New York (1947) ix + 415 pp.

19. WHITFIELD, G. B., T. D. BROCK, A. AMMANN, D. GOTTLIEB, and H. E. CARTER. Filipin, an antifungal antibiotic. Isolation and properties. Jour. Am. Chem. Soc. **67** (1955) 4799–4801.

ILLUSTRATIONS

[Photographs by Mr. Juan Sopeña]

PLATE 1

FIG. 1. Showing typical streptomyces growth of six isolates on Emerson agar slants.

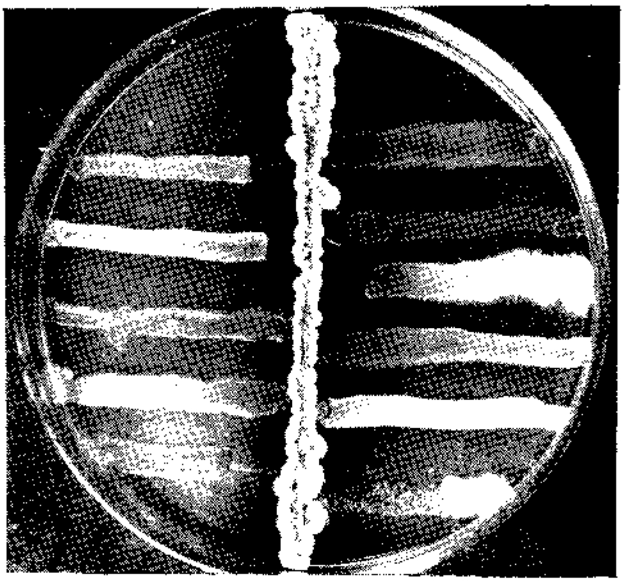
2. Showing an Emersion Agar plate with a streak of streptomyces at the center cross-streaked with test organisms five of which were inhibited.

PLATE 2

FIG. 1. Showing an assay plate seeded with *B. subtilis* on which were placed agar plaques of streptomyces for demonstration of antibiotic activity. Note Plaques 1, 2, 6, 9, and 10 on the outer circle and Plaque 1 on the inner circle showing varying degrees of growth inhibition.

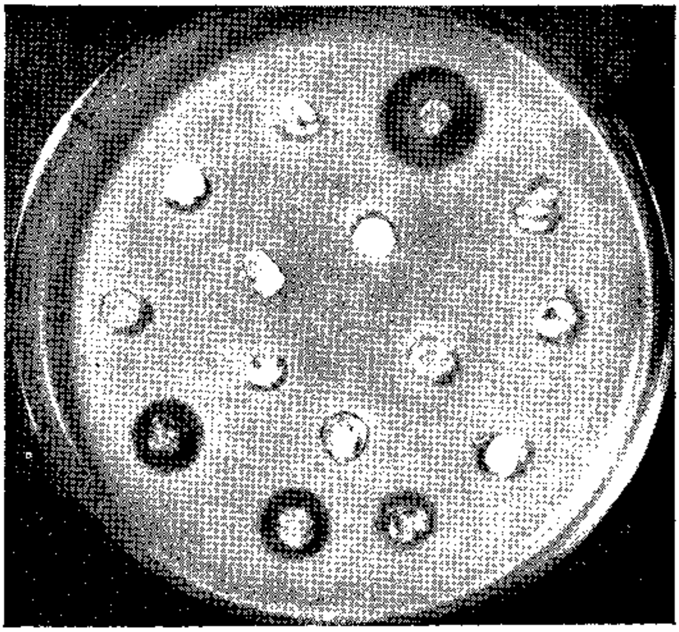
2. Showing an assay plate seeded with *P. æruginosa* with agar plaques of streptomyces for antibiotic activity tests.

1



2

PLATE 1.



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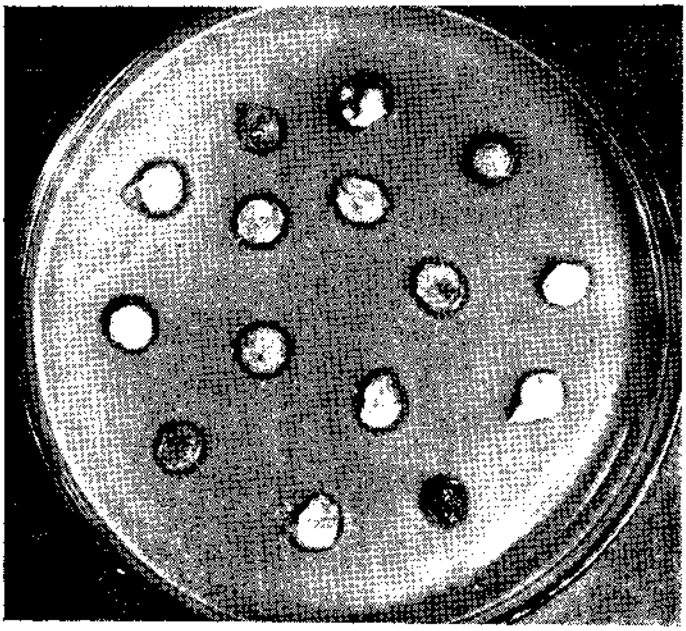

2

PLATE 2.

CRITICAL STUDY OF THE SAPONIFICATION VALUES OF NATURALLY OCCURRING FATS AND OILS

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In a previous critical study of the saponification values of coconut oil made by different proceses,[1] it was definitely established by the authors that a definite substance significantly affects saponification values. To a limited extent the saponification value of coconut oil is directly proportional to the amount of this substance present. Usually the coconut oil prepared by the dry-hot process (expeller) gives a lower saponification value than the cold-pressed oil from dried coconut meat. Likewise, coconut oil prepared from coconut milk or cream by rendering gives lower saponification value than oil prepared from coconut cream at low temperature like the quality water-white oil by the physico-mechanical process.[2] The saponification value of coconut oil prepared by the wet method is always higher than that of coconut oil prepared by the expeller process operated at higher or lower temperature.

By exhaustive elimination of this definite substance that significantly affects saponification values of coconut oil, washing it with salt solution or tap or distilled water, the lower limit of the saponification equivalent of what may be considered pure coconut oil, or 226.15, is obtained. Its saponification value is 248.06.

It will be interesting, therefore, to study other oils to find out whether this phenomenon is general or restricted only to coconut oil. This investigation includes (*1*) soya bean oil, (*2*) peanut oil, (*3*) pili-nut oil, (*4*) corn oil, (*5*) paring oil, and (*6*) coconut oil from "rubber copra" (dried meat of immature nuts), (*7*) premier jus, and (*8*) pork lard.

PREPARATION OF THE FATS AND OILS

(1) Raw soya bean bought from the market was dried in the oven, comminuted, and the oil extracted with ether. The extract was distilled to recover the ether. The residue was

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[1] Birosel and Gonzales, Philip. Jour. Sci. **90** (1961) 465–478.

[2] Birosel, D. M., U.S.A. Patent Office Serial No. 540588.

heated over a water bath to evaporate the ether, placed before an electric fan to eliminate the residual ether, then filtered, and made ready for use. The oil obtained was yellowish.

(2) Peanut oil was taken from the stock of another laboratory of the National Institute of Science and Technology. It must have been pressed from toasted peanut as it did not have the odor of raw oil. The oil was brown in color.

(3) Pili-nut oil was ether-extracted from grounded pili-nut kernels in the same manner as soya-bean oil. The ether-free filtered oil was greenish yellow though the kernel from which it was derived was white.

(4) The corn oil[3] was a by-product of a corn-starch factory located a few kilometers from Manila. This factory uses white corn for its raw material. The germ of the corn is white, but the oil pressed from it by a powerful expeller is brown, with plenty of suspended mucilagenous particles which soon settle at the bottom of the container.

(5) The paring oil[4] was pressed by expeller from the dried parings of coconut meat. Paring contains the brown coat plus a little white meat next to it. It is a by-product of desiccated-coconut factories. The oil is yellowish; the iodine value is much higher; and its saponification value is definitely much lower than the copra oil of commerce.

(6) The moldy rubber copra[5] was wiped clean with moist cloth, placed before an electric fan to dry, and comminuted to fine particles. The oil was ether-extracted as were two of the previously listed oils. Ether was recovered from the extract and the oil was freed thoroughly from the residual ether by heating over a steam bath for an hour. To remove completely the smell of ether, it was placed before an electric fan and then filtered. Dark-brown copra oil was obtained.

(7) Beef leaf fat found in the carcass cavity was freed from blood and washed. It was cut into small pieces and boiled in water until the tissue became soft. Liquid fat separated while boiling. The heat was put off and the pieces were allowed to cool sufficiently to be handled. These were placed

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[3] This oil was given the authors by Dr. Bernardo Acena of the Plant Utilization Division of the Bureau of Plant Industry, a technical consultant of the factory.

[4-5] Paring oil and rubber copra were given the authors by Mr. Jose Vibar, chemist-superintendent of Scheteleg Oil Factory of San Pablo City.

in cheesecloth and pressed. The residue, which still contained fat, was further boiled in the same water and again pressed. All the yield of fat was remelted and, to get rid of the water, gently heated and continuously stirred. It was doubly filtered warm, placed in a covered glass jar, and stored at the bottom chamber of a refrigerator. After years of keeping, it was still a fairly good premier jus. Freshly prepared premier jus has a butterlike flavor.

(8) A kilo of pork fat was bought from the market. After washing and cleaning and the water drained, it was cut into small pieces and immediately rendered. The pork fat was white but the pork lard obtained was slightly yellowish. Filtered hot, it had an agreeable pork odor.

A definite volume of the prepared oil, 250 cc, was placed in a 1-liter separatory funnel. Two volumes of 3 per cent salt solution was added and the immiscible liquids were shaken vigorously for a few minutes and several times. Both liquids became opaque. A half-hour to one-hour gravity separation was allowed to elapse before the salt solution was discharged. The salt solution carried away a portion of the substance that increased the saponification value of the oil. The salt washing was followed by two or three or more washings with tap water. Two volumes of tap water were used. The immiscible liquids were shaken vigorously for a few minutes and repeatedly, followed by tap-water washing. Washing the oil in this manner produces an emulsion state in which water globules are dispersed in oil as a continuous phase and the substance that increases the saponification equivalent of oil acts as emulsifier of the system. After extraneous water has been eliminated, the oil is gently heated to dry. Whenever salt solution or tap water is used for washing the oil, there are always fine solid particles suspended in the drying oil and these fine solid particles remain on the filter.

When soya bean oil was subjected to washing with salt solution as described above, the emulsion was quite voluminous and had the appearance of mayonnaise—an emulsion of salad oil and lemon juice or good quality vinegar and finely powdered mustard stabilized by egg yolk. The longer it was shaken with the salt solution the more firm the mass of emulsion became. The extra salt solution readily separated at the bottom. It was opaque owing to the presence of dissolved phospholipid.

After discharging the opaque salt-solution, the semisolid emulsion was washed several times with two volumes of tap water. Each successive washing of tap water became opaque also. After much of the extraneous water was discharged, kneading to separate the remaining water could not be applied as this emulsion system did not solidify at the freezing chamber of the refrigerator. Heating the emulsion until it boiled and then allowing it to cool separated the extraneous water, which was eliminated by siphoning. The residue was heated gently to dry the oil and continuously stirred to prevent bumping. As the water globules disappeared, fine solid particles were left behind. When the dry oil was allowed to cool, the fine solid particles settled at the bottom. The oil was filtered and the fine solid particles, which remained on the filter paper, appeared yellowish. The filter containing the solid particles was pressed between filter paper to absorb the oil. A portion of it was suspended in a few cc of distilled water and vigorously shaken. It was filtered and the solution was tested for the presence of sodium chloride. Sodium revealed itself by flame test. Two or three drops of silver nitrate solution added to a portion of the filtered solution revealed the presence of chloride ions. This test was made for all the solid particles obtained from each oil showing positively the presence of sodium chloride. The solid particles were found positive for phosphorus, nitrogen and chloride ion. Sulphur was negative.

Every time dry oil was obtained, the saponification value was determined. The balance of the oil left was again washed with salt solution and afterwards washed many times with tap water. Dry oil was again produced and the saponification value was again measured.

After each successive set of washings, the oil emulsion became less and less voluminous; and, towards the end, the soya bean oil washed many times behaved like coconut oil which does not form a voluminous emulsion. The oil separated less densely on the top of the aqueous solution and both layers were still opaque but less so than at the beginning of the washing operations. When the last two consecutive saponification values varied only a few digits to the hundredth decimal point, the washing was stopped. At that point the amount of the substance that affected the saponification equivalent had almost reached its vanishing point and there were left almost pure fatty-acid glycerides called oil, which had no phosphorus and nitrogen in their molecular composition.

Corn oil was observed to behave like soya-bean oil producing voluminous emulsion. However, after the fourth washing with salt solution, three or four washings with tap water, then drying the oil and obtaining its saponification value after it had cooled, a subsequent washing with salt solution did no longer give a voluminous emulsion (see Table 1) and a greater portion of the emulsifier had been eliminated. From the fifth to the end of the washings, the washed corn-oil behaved very much like coconut oil.

Pili-nut oil, paring oil and rubber-copra oil gave no difficulty in the elimination of the substances that increases the saponification value of the oil. The washing of these oils, together with copra oil and quality coconut oil, may be considered normal. The characteristics of these oils, insofar as their purification through the elimination of the substance that affects their saponification values is concerned, may be inferred from the data shown in Table 1.

THE SOLID EMULSION OF WATER-IN-FAT SYSTEM

About 250 gms of good premier jus kept in the refrigerator over three years was exhaustibly washed with salt solution and tap water twice its own weight to eliminate the phospho-nitrogen-containing substances (tentatively designated as phospholipid) that affects the saponification value as well as the saponification equivalent of the fat. Since beef fat has a rather high melting-point, the salt solution, as well as the water, was prewarmed before use. The melted fat was transferred into a 1-liter separatory funnel and 3 per cent warm salt solution added. The immiscible liquids were shaken vigorously for five minutes and the process repeated several times. Half an hour was allowed for gravity separation, after which the lower layer was discharged. This was followed by washing eight times with warm tap water twice the weight of the fat. At the end of the eighth washing, much of the extraneous water was eliminated. The fat was cooled to harden for kneading. It had to be hardened properly or it would not knead smoothly but would stick to the blade of the spatula. By practice, one gains the right technique.

The presence of extraneous water was determined by testing. The fat was melted and allowed to stand. The absence of a pool of water or big drops at the bottom of the container would show that all extraneous water had been eliminated. Since there was water after allowing the fat to settle, the upper layer was gently poured into a beaker and the lower layer into another. The beaker containing the lower layer was put back into the refrigerator to solidify before it was kneaded. The two portions were put together and remelted to examine the presence of extraneous water. When the fat was found free from it, the emulsion was mixed thoroughly to produce a homogenous mass and then poured into two beakers in unequal portions. The weights of the portions were taken and each portion was gently heated and continuously stirred to dry the fat. It was allowed to cool and the dry weight was measured. Observed at the bottom of the container were fine solid particles which were left by the membrane of the water globules. The data pertaining to this performance follow:

	I	II	S.V.
Weight of emulsion	57.50	58.90	195.43
Weight of dry fat	56.25	57.70	
Weight of water globules	1.25	1.20	
Percentage of water	1.25 ÷ 57.50 = 2.17;	1.20 ÷ 58.90 = 2.04	

The ratio of water to oil in this solid emulsion of water-in-fat system is close to two parts water to ninety-eight parts beef fat. This ratio does not seem to be a fixed value as will be shown in the next performance.

The residual fat was washed with salt solution followed by six washings of tap water and another salt washing. The emulsion was freed from salt by two washings with tap water. Extraneous water was next eliminated following the technique previously applied. The data pertaining to this performance follow:

	I	II	S.V.
Weight of emulsion	39.20	42.45	193.63
Weight of dry oil	37.90	41.05	
Weight of water	1.30	1.40	
Percentage of water in the emulsion		1.30 ÷ 39.20 = 3.32 1.40 ÷ 42.45 = 3.30	

The ratio of water to beef fat in this emulsion system is 3.31 parts water to 96.69 parts beef fat. In other words, a better emulsion system is obtained in this performance than in the previous one.

The third performance consisted of three washings with salt solution: the first two washings with salt solution were followed by three tap-water washings, and the third salt washing was followed by two tap-water washings to free the emulsion from salt solution. Then the emulsion system was freed from extraneous water. The data pertaining to this performance follow:

	I	II	S.V.
Weight of emulsion	32.45	39.35	192.25
Weight of dry oil	31.05	37.60	
Weight of water	1.40	1.75	
Percentage of water in emulsion		1.40 ÷ 32.45 = 4.31	
		1.75 ÷ 39.35 = 4.45	

The ratio of water to beef fat in this emulsion is 4.38 parts water to 95.62 parts beef fat, a ratio which is higher than those of the preceding two determinations. As long as the amount of the phospholipid substance is high, the ratio will increase if the shaking of the immiscible liquid is done more efficiently.

The fourth performance consisted of three washings of salt solution, each of which was followed by two washings of tap water. After eliminating extraneous water by careful kneading until not one drop of water collected at the bottom after letting the warm emulsion stand for a few minutes, the emulsion was homogenized by stirring. Two unequal portions were weighed and afterwards each was separately dried by heating slowly and stirring continuously until water globules completely disappeared leaving them fine solid particles. The dry oil was allowed to cool in front of an electric fan and afterwards each portion was weighed. The data pertaining to this performance folow:

	I	II	S.V.
Weight of emulsion	23.15	32.40	191.8
Weight of dry oil	22.50	31.50	
Weight of water in the emulsion	0.65	0.90	
Percentage of water in the emulsion		0.65 ÷ 23.15 = 2.80	
		0.90 ÷ 32.40 = 2.78	

The ratio of water to beef fat in this emulsion is 2.79 parts water and 97.21 parts beef fat, a ratio lower than the preceding one. The phospholipid substance had been so decreased that there was not enough emulsifier to envelop the greater number of water globules. From here on the ratio will always come out less.

The fifth performance consisted of two washings of salt solution; the first was followed by six washings of tap water and the second by two washings of tap water to free the emulsion from salt. Extraneous water was eliminated as done above and the oil was dried with the use of the same operational procedure. The data pertaining to this performance follow:

	I	II	S.V.
Weight of emulsion	23.40	22.40	191.79
Weight of dry oil	22.95	22.00	
Weight of water in the emulsion	0.45	0.40	
Percentage of water in the emulsion		0.45 ÷ 23.40 = 1.91 0.40 ÷ 22.40 = 1.78	

The ratio of water globules to beef fat in the emulsion is 1.85 parts water to 98.15 beef fat, which ratio is lower than the preceding one and attests to the diminishng amount of the substance that markedly affects the saponification value of premier jus of beef-leaf fat.

One-quarter liter of melted pork fat was subjected to the same procedure applied to premier jus to eliminate the definite substance or substances that affect its saponification value. The data obtained appear in Table 1.

TABLE 1.—*Progressive reduction of the saponification values of different fats and oils after series of washings with salt solution and tap water.*

Fats and oils	Saponification values							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Soy bean oil	191.45	190.10	189.97	189.75	189.74	.....	.....	.....
Peanut oil	192.05	190.36	190.17	189.61	189.22	189.10	189.07	.....
Pili-nut oil	194.47	193.54	193.05	192.82	192.76	192.74	.....	.....
Corn oil	188.89	188.72	188.03	185.94	185.79	185.45	.....	.....
Paring oil	237.84	237.45	236.29	235.35	235.09	234.85	234.76	234.71
Rubber copra oil	250.15	249.20	248.06	.....	.....	.....	.....	.....
Beef fat	196.00	195.80	195.43	193.63	192.25	191.81	191.79	191.70
Pork lard	196.26	195.36	194.82	194.17	193.56	193.22	193.16	.....

DISCUSSION

The significance of the decrease in the saponification values of different fats and oils toward the end of the elimination of the particular substance or substances that affect the saponification value is very obvious. The substance increases this chemical constant of oil and fats. The phenomenon appears to be general rather than restricted to coconut oil in which it was first observed.

As in the case of coconut oil, this particular substance in the oils and fats under study also contains phosphorus and nitrogen besides hydrogen, carbon and oxygen. It shows the characteristics of a phospholipid. It is soluble in fats and oils and shows good affinity for water. It unites or combines with sodium chloride to form the salt-phospholipid emulsifier complex system of fats and oils and produce a water-in-oil emulsion from an oil-in-water emulsion, the type to which coconut milk and cream belong.

Like a phospholipid, it is subject to oxidation and gives a colored salt-complex, which shows that its molecular structure contains an unsaturated group. In the presence of water it adds water-forming bodies which show opaque characteristic of coconut milk and cream and to the opaque characteristic of the water-in-oil type of emulsion in which fats and oils are formed when they are violently shaken with water or salt solution.

There are two materials in the present study from which milk can be prepared from the fresh kernel. These are soya bean and coconut. Soya-bean milk has been used by the Chinese for centuries and was introduced into the Philippines several years before the last war. Coconut mlk is used for culinary purposes. The production of home-made oil from the coconut has existed since time immemorial here and in other Oriental countries.

Soya-bean milk and coconut milk are naturally opaque emulsion systems of oil-in-water. The emulsifier system in both types of milk must be the phosphorus- and nitrogen-bearing substances that are present in the bean or nut kernel. In the case of the soya bean, which has been studied by more-experienced researchers in America, Europe and Japan, the phospholipids[6] found have been identified as principally lecithin, and cephalin mixed with it in a smaller amount. Commercial lecithin is prepared from soya bean. Crude soya-bean oil is reported to contain about 1.8 per cent phosphatides[7] though it may contain as much as 3.2 per cent. It is the authors' experience in this present study to note the difference between soya-bean oil and coconut oil in their ability to produce emulsion systems when separately shaken with either salt solution or tap water. Soy-bean oil makes a voluminous emulsion at the start while coconut oil gives a nonvoluminous emulsion system to the end. This is due perhaps to the different phospholipids dealth with. Soya bean is predominantly lecithin, while coconut may contain a different kind. When the amount of lecithin in soya-bean oil has been materially decreased by the process of elimination, the emulsion prepared is nonvoluminous, something similar to what coconut oil gives—a nonvoluminous, emulsion type. It has also been observed that when the soya-bean oil nonvoluminous emulsion is dried by slow heating and continuous stirring, the fine solid particles that are left by the disappearing water-globules appear grayish in color rather than yellowish. Salt-lecithin is eliminated much faster than cephalin, though the latter is present in soya-bean oil in a smaller amount.

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[6] Chibnal, A. C., and H. J. Channon. Biochem. Journ. **21** (1927) 225–232, 233–246, 479–483, 1113–1120. Susuki and Yokohama, Proc. Imp. Acad. Tokyo **6** (1930) 341–344, Ibid. **7** (1931) 12–14. Hildith and Fedilty, Biochem. Journ. **31** (1937) 1964–1972.

Premier jus, besides containing phospholipids, contains cholesterol. Cholesterol is hydrophobic while phospholipids are hydrophylic. Premier jus does not produce a voluminous emulsion system though, like soya-bean oil, it contains more lecithin than other phospholipids. The presence of cholesterol in premier jus explains why we do not obtain a voluminous type. Cholesterol tends to limit the surface occupied by lecithin. The observation noted in soya-bean oil is also noted in premier jus. Here again lecithin is eliminated much faster than cephalin though the latter is present in a smaller amount. Pork fat gives the same type of emulsion system as premier jus. It contains the same emulsifiers, which are cholesterol and phospholipids. Corn oil gives the same type of emulsion system as soya-bean oil. Its emulsifier may be of the order of lecithin.

It looks as though the phytosterol of vegetable oils did not have the characteristic of its opposite the cholesterol of animal fats. Phytosterol does not limit the surface occupied by lecithin so that vegetable oils, like soya-bean oil and corn oil, which contain lecithin in great amounts, form voluminous emulsion systems. Pili-nut oil, paring oil, rubber-copra oil and peanut oil produce nonvoluminous emulsion systems. They probably have the same kind of emulsifier. As in coconut oil, the salt-emulsifier complex left by the disappearng water globules in their respective emulsion systems (when the dry oil is recovered by heating gently and stirring continuously) consists of fine, dark or grayish solid particles. This, in itself, is the distinguishing characteristic of fine, dry, solid, salt-cephalin complex. There is then a strong indication that cephalin is the phospholipid predominantly present in coconut, with the possible presence of lecithin but in lesser amount.

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[7] Kaufmann, H. P. Fette u. Seifen 48 (1941) 53–59.

The phospholipids of coconut oil will be dealt with in detail in another paper by the same authors.

SUMMARY

1. The phenomenon regarding the presence of a substance that increases the saponification value of coconut oil noted first in the critical study of saponification values of the oil made by different processes is found in evidence in other naturally occurring fats and oils and is therefore not restricted to coconut oil only but of general occurrence.

2. Soya-bean oil and corn oil have been observed to form voluminous water-in-oil emulsions at the start of the elimination of the substance that affects their saponification values but they gradually lose this property as the elimination progresses and finally their emulsicn systems become nonvoluminous. This points to two sets of emulsifiers with different properties.

3. The oils from ground pili-nut and coconut give nonvoluminous water-in-oil emulsion systems from the start of the elimination of the substance that affects their saponification values. Their emulsifiers must be of a sort different from that of soya-bean oil and corn oil.

4. Animal fats, like premier jus and pork lard, give nonvoluminous water-in-oil emulsion systems.

5. The phospholipids of these oils and fats combine with salt when shaken separately with salt solution to form salt-complex substance which was labelled salt-phospholipid complex containing sodium, chlorine, phosphorous, and nitrogen, func-

tioning as the emulsifier-estabilizer system of the water-in-oil emulsion formed.

6. Vegetable oils and animal fats differ in their sterols; the former contains phytosterol while the latter contains cholesterol. It appears that phytosterol does not have the restraining effect of cholesterol on the propensity of lecithin to occupy big volume space.

7. Whichever phospholipid—lecithin or cephalin—is predominantly present in vegetable oil will determine the nature of the emulsion system it can form, which is eitheir voluminous or nonvoluminous.

The authors have planned to study more extensively the emulsifier system of coconut milk and cream and the phospholipids present in coconut oil.

THE BLUE-GREEN ALGÆ OF THE PHILIPPINES

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INTRODUCTION

THIRTEEN PLATES

Studies of the class Myxophyceæ in the Philippines have been limited to short investigations mostly done by the author and published since 1941 in the Natural and Applied Science Bulletin of the University of the Philippines. The publications of Dr. Joventino D. Soriano on the Myxophyceæ of Panay and Negros islands and his Studies on the Myxophyceæ of Manila and vicinity added more information especially on the ecology of the species.

This work includes all the known specimens in the Philippines of the blue-green algæ, which number 162 species and 3 forms belonging to 33 genera and 8 families. Most of the specimens re-examined have been deposited in the Cryptogamic Herbarium of the Chicago Natural History Museum since before World War II. There are also included in this study a good assemblage of Philippine materials mostly collected by former botanists who visited the Philippines, and deposited in the U.S. National Museum, New York Botanical Garden, and Herbarium of the University of California. It was indeed our great fortune to have about half of the materials studied safely kept in foreign institutions, otherwise, they would have been burned during the liberation of Manila on February of 1945. The original materials deposited in the Cryptogamic Herbarium of the University of the Philippines and those distributed to the Philippine National Museum for exchanges were reduced to ashes.

Of great addition were the numerous materials collected by the pioneers of Philippine botanical study, among whom were R. C. McGregor, H. H. Bartlett, E. Quisumbing, C. B. Robinson, W. R. Shaw, and E. D. Merrill, whose collections dated from as early as 1903 to 1935. The collections of R. P. Cowles, E. Fenix, A. D. E. Elmer, H. C. Herre, L. E. Ebalo, M. T. Cruz, J. Redondo, and G. C. Alcasid added a very significant amount to the then enormous assemblage of known materials. These names deserve to be in the epithet of Philippine phycology in due recognition of their unselfish interest for plant collection coupled with an effort to increase the botanical knowledge of the Philippines which had just started to develop at the time. The study and subsequent acquisition of these collections were readily incorporated in the writing of this work.

OPPORTUNITY FOR STUDY AND ACKNOWLEDGMENT

The author was a recipient of the John Simon Guggenheim Memorial Foundation fellowship late in 1956 which was spent in the United States from December 3, 1956 to October 22, 1957. As a counterpart in recognition of this Guggenheim fellowship, the University of the Philippines granted a special detail of one year in order to be able to pursue abroad the specialized study. Below in tabulated form are the institutions visited and where accommodation was extended most courteously during the studies devoted for the completion of the work. I wish to acknowledge my indebtedness to friends in the botanical sciences and librarians in the six institutions of the itinerary enumerated below without which this work could never have been realized. At the same time the Biological Library of the University of Chicago, the John Crerar Library at Randolph Street, the Library of the Chicago Natural History Museum, the Library of the Life Sciences of Northwestern University at Evanston, and the private library of Dr. F. Drouet were of incalculable assistance during the progress of the work in supplying so many original references now out of print, written from 50 to more than 100 years ago. Finally the difficult task of making the illustrations passed through the hands of Misses Patrocinio P. Makabenta, Araceli B. Gonzales, Daisy T. Boquiren and Ernesta C. Galutira, supported by research grants from the Natural Science Research Center of the University of the Philippines.

LITERATURE

Most of the original studies of the blue-green algæ in the Homocystineæ are available in M. Gomont's Monographie des Oscillariees 1893 while those of the Heterocystineæ in E. Bornet and Ch. Flahault's Revision des Nostocacees Heterocystees 1886-1888. On the other hand, studies of the unicellular forms could best be referred to F. Drouet and W. A. Daily's Revision of the Coccoid Myxophyceæ in 1956. Other available literature are L. Geitler's Vol. 12, Cyanophyceæ, pp. 1-450 in A. Pascher's Die Süsswasser Flora Deutschlands, Osterreichs und der Schweiz, 1925; Geilter's Cyanophyceæ, 1932; and Pierre Fremy's Les Cyanophyceæ des Cotes d'Europe 41 (1934) 1–236. Three excellent articles of Y. Bharadwaja in the class Myxophyceæ were the main sources of very useful information utilized during the progress of this work. Other references and aids consulted were those of J. D. Soriano and the experience of the author for over a decade of teaching and studying the Philippine Myxophyceæ.

Institution	Time spent	Nature of accommodation
1. Cryptogamic Herbarium of Chicago Natural History Museum	December 3, 1956 to July 8, 1957	Dr. Francis Drouet furnished the facilities to examine all Philippine blue-green algæ collected before World War II, the duplicates of these specimens were burned in the Philippines. Ample opportunity to examine the blue-green collections from Asia and Oceania were also extended in making comparative study of the Philippine materials.
2. Libraries of the University of Michigan	July 11 to August 9, 1957	Library assistance was made by the late Prof. Harley H. Bartlett to complete as much as possible the literature written on the Philippine algæ. The facilities of the Biological Library, the General Scientific Library of the University of Michigan and the Museum extended full cooperation.
3. United States National Museum, Smithsonian Institution	August 12 to 19, 1957	Dr. Mason E. Hale gave free access to the algal collection of Cryptogamic Botany, and library of the Department of Agriculture at Washington, D.C.
4. The New York Botanical Garden	August 22 to 29, 1957	Dr. David D. Keck gave free examination of the algal section of the Cryptogamic Herbarium. Miss Elizabeth G. Hall, chief librarian, furnished the rare references for further completion of the bibliography.
5. Farlow Library and Herbarium of Cryptogamic Botany of Harvard University	September 3 to 13, 1957	Dr. I. MacKenzie Lamb furnished all facilities of examining the Philippine blue-green algæ in the herbarium. Mrs. Lamb, on the other hand, rendered special effort in procuring more references which had not been located so far in the course of study of the Philippine blue-green algæ.
6. University of California at Berkeley	September 18 to October 22, 1957	Dr. George F. Papenfuss generously extended complete accommodation in examining the Philippine blue-green materials in the algal section of Cryptogamic Botany. His graduate research student, Mr. Kung Chu Fan, assisted in procuring additional references which further enriched the knowledge of the Philippine blue-green algæ.

HABIT AND DISTRIBUTION

The blue-green algæ are world-wide in distribution and observed to live in all habitats from deep ravines to summits of mountains. About three fourth of the species from the Philippines are found in countries bordering the Pacific, such as Hawaii, Santa Cruz and Solomon Islands, Bikini, Java, and Japan.

Permanent ditches, street canals and esteros rich in organic compounds abound with species of *Oscillatoria, Phormidium, Lyngbya,* and independently living unicellular forms. The immediate surroundings of these places, which remain moist throughout the year, yield, besides the species above, terrestial forms like *Microcoleus* and *Anabæna.* The sidewalks in many gardens and kitchen premises which remain always moist exhibit very good growth of terrestrial blue-green algæ. The water "bloom," common in ponds, lakes, and quiet rivers during warm months, is composed of *Anacystis cyanea* Drouet & Daily, *Oscillatoria* and sometimes *Anabænopsis.* These waters during some summer months oftentimes afford special growth to the planktonic species of *Oscillatoria* and *Spirulina. Nostoc* balls, *Anabæna,* and coccoid forms constitute the bulk of collections in some rice fields and many open spaces. Steep roadside embankments give luxuriant growth of *Coccochloris stagnina, Porphyrosiphon Notarisii,* two or three species of *Scytonema, Schizothrix,* and *Lyngbya.* Scattered unicellular forms are quite common throughout the year in waterfalls and cliffs under dripping water. Hot springs which register as high as 74°C give excellent growth of *Phormidium laminosum* and *P. valderianum.* The different hues of color exhibited by this growth during the different months of the year contribute to the attractive landscape of the vicinity.

Fishponds in brackish water are usually covered with thick blackish mats of *Lyngbya æstuarii.* In salt water along the intertidal zones, *Symploca Howei, Lyngbya majuscula, Phormidium Crosbyanum* and a sterile *Anabæna* species are very common collections. *Brachytrichia Quoyi* in corrugated irregular balls of various macroscopic sizes grow luxuriantly on boulders of rocks, while along shore lines splashed by salt water during high tide may be collected thick felty growth of *Calothrix pilosa* and *Gardnerula corymbosa.*

MORPHOLOGY

The members of the class Myxophyceæ have no chloroplastids, the principal pigments of phycocyanin (blue) and chlorophyll (green) being diffused throughout the peripheral portion of the protoplasm. These two pigments gave the name blue-green algæ to the group. Xanthophyll and a special phycoerythrin pigments are present unusually in some species. The color variation among some representatives of the class must be due to the different concentrations of these pigments in the cell, aided possibly by the effect of sunlight, nutrition, pH, maturity and other environmental factors. The reserved food is glycogen or glycoproteins.

The central portion of the cell occupied by coarse granulation is identified as a false nucleus. There are chromatinic structures observed in many species, such as *Phormidium favosum, P. Retzii, Schizothrix Mulleri,* and *Oscillatoria tenius,* which behave similarly as chromosomes in ordinary cell division. They exhibit positive reaction to Hædenhein's iron allum hæmatoxylin, which readily stains the chromatin granules. Outside the false nucleus is the cytoplasm of fine granulation invested with a thin membrane, the ectoplast, and an outer membrane, the sheath or mucilage. The sheath may be thin and almost negligible in some species, others show marked evidence which developed conspicuous lamellations characteristic of the species. Thin or thick homogeneous sheaths observed in many species are due to various effects of hydrolysis.

Fission is the principal method of reproduction. When sufficient number of cells are formed in the colonial and filamentous species, the big groups of cells break into fragments to form new colonies in the former, or separate into short pieces known as hormogones in the latter. Endospores and exospores are formed in very limited groups while akinetes or special spores are common occurrences among the filamentous forms. Sexual reproduction is unknown in the Myxophyceæ.

SPECIES LIMITATION

It is evident that the various climatic factors affecting the blue-green algæ in the Philippines are similar to those factors affecting the various species of the Pacific. The great northern and southern equatorial currents, after following their natural courses, converge in the eastern and southern shores of the Philippines. At the same time, the great currents moving along the China Sea should also exert a great influence to the flora of the country. All other possible algal habitats bordering the vast Pacific are exposed to the same climatic disturbances. When factors of environment are similar, even the genes which cause major or minor variations in the species are relatively important to consider algal speciation. It will not be surprising therefore to discover marked similarity of the blue-green algæ thriving all over the Pacific area. These primitive forms of algæ had long lived in the environment, equipping themselves with the changes they now possess as a result of their continuous adaptation towards the balance of nature.

Observation and measurement were made exclusively from the available local materials. In some specimens, it was necessary to indicate two measurements, one represents the actual measurement from the material, and the other in parenthesis, the record from the type species described in the reference. In some local materials which have unusually very limited representation, the measurements differ conspicuously, otherwise, no difficulty was encountered during the whole process of studying the specimens under the microscope.

COLLECTION, PRESERVATION AND STUDY

The blue-green algæ thrive in all sorts of habitat—dry, moist and mostly in water. In ordinary collection on moist soil surfaces, one needs only to scrape carefully with an ordinary knife from the peripheral part of the living specimen and transfer carefully topside exposed to a newspaper sheet. Allow to dry in the open air, never directly under sunlight or in the press usually directly subjected to high temperature. Materials prepared under gradual drying preserve the natural characteristics of the specimen. Planktonic species brought to the laboratory may pass the centrifuge and afterwards allowed to dry on white paper. Where facilities are incomplete, the materials may be put directly in liquid preservatives temporarily, centrifuged in the laboratory and washed in water as soon as possible. They are allowed to dry as usual in mica sheets, celluloid slips, or ordinary newspaper.

There is no better method employed in microscopic or gross examination of the specimens than using directly fresh materials. But when this is not available as what happened in confirming the materials used in this work, a sample of the dried material may be put into a drop or two of a dilute solution of detergent. This detergent gets into the material gradually thus preparing the specimen thoroughly for examination. Dilute solution of iodine or methyl green ordinarily reveals clearly the cell structures and the sheaths of some species. Rare materials should always be returned to the packets after drying slowly on mica sheets.

HERBARIUM DISTRIBUTION

The herbaria in which the specimens used in the investigation are to be found, together with their abbreviations, are indicated in the following list adopted from Regnum Vegetabile vol. 15, Index Herbariorum, Part II, Herbarium Abbreviations, pp. 188-211, by. J. Lanjouw and F. A. Stafleu, 1959: PUH, Herbarium of the Discipline of Botany, College of Arts and Sciences, University of the Philippines; PNH, Philippines National Herbarium; FC, Cryptogamic Herbarium, Chicago Natural History Museum; NY, New York Botanical Garden; FH, Farlow Library and Herbarium of Cryptogamic Botany, Harvard University; US, United States National Museum, Smithsonian Institution; and UC, Herbarium of the University of California at Berkeley.

Key to the order

1. Plant mass unicellular, in colonial forms, quite variable, pseudofilamentous in some species .... Chroococcales
1. Plant mass always filamentous .... Hormogonales

Order CHROOCOCCALES

The great majority of these plants are unicellular, solitary or associated in simple or complex colonies generally invested by gelatinous matrices; others form strata, cushions of pseudoparenchymatous cells and pseudo-filaments. General reproduction is by fission of one cell into two daughter cells, endospore formation being quite common in pseudo-filamentous forms, and breaking of large colonies or fragmentation is common in many species.

The members of the order Chroococcales represented largely by the family Chroococcaceæ are generally the coccoid forms of the class Myxophyceæ treated in this work. They constitute seven species and two forms. A smaller family; namely, Chamæsiphonaceæ, is represented by only two species and one form. Their genera, *Entophysalis* and *Stichosiphon*, have been suitably included in the key below.

Key to genera

1. Cell formation always colonial 2
1. Cell formation variable, mostly cushionlike 4
    2. Colonial formation flat of regularly arrange rows of cells perpendicular to each other within a gelatinous matrix ...... *Agmenellum*
    2. Colonial formation of irregularly arranged cells within a solid or diffluent gelatinous matrix 3
3. Cell division in one plane at right angle to the axis of the cell. *Coccochloris*
3. Cell division in three planes perpendicular to each other ... *Anacystis*
    4. Cushion-like, generally forming endospores .... *Entophysalis*
    4. Epiphytic, pseudo-filamentous .... *Stichosiphon*

Genus AGMENELLUM Brebisson, 1839

Plants usually flat, microscopic, scanty or much expanded to macroscopic size; cell division in two series at right angles to each other, cells in gelatinous hyaline matrices, spherical when young and ovoid when matured.

AGMENELLUM THERMALE (Kutzing) Drouet and Daily. Plate 1, fig. 1.

Agmenellum thermale (Kützing) DROUET and DAILY, Butler Univ. Bot. Stud. **12** (1956) 89.

Plants greenish to blue-green, much expanded, lamelloid up to 4 cm long, narrower in many specimens, generally irregular and indefinite in growth; sheath consepicuous, hyaline, becoming diffluent; cells at first ovoid, 4 to 10 μ in diameter, soon conspicuously arranged at right angle to each other; protoplasm pale blue-green, homogeneous or finely granular.

The species invariably inhabits also vicinities of salt beds as found later at Parañaque, Rizal.

Specimens examined.—LUZON: Rizal: in Dagat-dagatan, Navotas: dull blue-green growth with *Anabæna torulosa* on surface of muddy flat, 441, February 12, 1940 (PUH, PNH); pale blue-green growth on moist soil, *H. Rabanal* and *G. T. Velasquez 442*, February 12, 1940 (PUH, PNH).

Genus COCCOCHLORIS Sprengel, 1807

Plants microscopic to macroscopic; cells usually in gelatinous diffluent matrices, spherical when young, becoming oval or elongate in maturity; cell division in only one plane perpendicular to the axis of the cell.

Key to the species of Coccochloris

1. Matured cells ovoid to cylindrical, generally 5.5 μ wide . . . *C. stagnina*
1. Matured cells always cylindrical, 1 to 3 μ wide . . . . . . *C. Peniocystis*

COCCOCHLORIS STAGNINA Sprengel. **Plate 1, fig. 2.**

C. stagnina SPRENGEL, Fl. Halens, Mantissa 1 (1807) 14.

Colonies of few to many cells, generally blue-green, of variable sizes, shapes, and colors; cells with truncate ends after division, becoming oval and pear-shaped on maturity, many with distinct lamellose sheaths, others diffluent, 8.5 μ long and (4.8) 5.9 μ wide, on the average.

This species usually occurs abundantly as lumps of small or big irregular mucilaginous balls on rocks under dripping water or in soil fairly rich in organic matter; many exist as free-floating tiny colonies with other algæ. Except sometimes for coarser granules, dissociated akinetes and ordinary cells of some *Nostoc* species are always mistaken for cells of *C. stagnina*.

Specimens examined. — LUZON: Bataan: dark blue-green growth with mosses on damp stone walls in Balanga, 2404, July 12, 1950 (PUH, PNH); dull blue-green growth on moist stones and soil near the river bank at Panilao, Pilar, 2412, July 13, 1950 (PUH, FC); Batangas: floating abundantly in rice fields at Lipa, 595a, January 12, 1941 (PUH, PNH, FC); Ilocos Norte: blackish growth on moist bank beside Banna waterfalls, 2242, June 5, 1950 (PUH, PNH); dark blue-green growth floating on a pool in river bank near bridge at Laoag, 2245, June 6, 1950 (PUH, PNH); dull to dark blue-green growths on moist soil in corn field at Baay, Batac, 2260, June 8, 1950 (PUH, PNH, FC); dull blue-green growth on dry side of Banna river, 2263, June 9, 1950 (PUH, PNH); dull blue-green growth on moist sandy shore of river at Banna, 2264, June 9, 1950 (PUH, PNH): blue-green to yellow-brown thick mucilaginous growth floating in a fishpond at Butnong, Pasuquin, 3626, April 24, 1955 (PUH, PNH). PANAY: Iloilo: on damp interior walls exposed to sun and rain of the ruined Catholic Church at Sta. Barbara, JDS, 1038, June 23, 1952 (PUH, PNH, FC). LUZON: Laguna: in Los Baños, dull blue-green growth in hot spring, Talakay, 2465, August 8, 1950 (PUH, PNH); dark blue-green growth in hot spring at Talakay, 2465, August 8, 1950 (PUH, PNH); growing on stone fence of Dr. Capinpin's residence, 3723, December 28, 1955 (PUH, PNH). LEYTE: pale green to light olive-green, extremely gelatinous and semirigid masses about 1/4" thick floating in inshore areas of pond in coral pit near Tacloban airstrip, *M. E. Britton 153*, October 10, 1945, (PUH, FC). MINDORO: Oriental Mindoro: all in Puerto Galera: growing on wall of artesian well at Small Tabinay, 729, April 2, 1941 (PUH, PNH); dull greenish growth in a small pond at Big Tabinay, April 7, 1941 (PUH); dark blue-green growth on a drying pond of brackish water at Big Balatero, 944, April 22, 1941 (PUH, PNH); dull blue-green growth along the highway near the water bridge, Bisayaan, 1954a, May 25, 1949 (PUH); growing with *Rhizoclonium hieroglyphicum*, etc., *Nostoc Linckia, Oscillatoria sancta* at Big Balatero, 7, April 25, 1953 (PUH, FC). PALAWAN: grayish blue-green growth on rocks along a dry canal at Osmeña Street, Cuyo, 2848, June 9, 1951 (PUH, PNH). LUZON: Rizal: dark blue-green growth floating on rice paddy at Barrio Mangahan, Pasig, *JDS 935,* May 18, 1952 (PUH, PNH, FC); growing near the faucet in front of library building at Parañaque, 3710, December 28, 1955 (PUH, PNH); dull blue-green growth on adobe stones in front of Antipolo church, 3764, February 20, 1956 (PUH, PNH); Manila: light blue-green growth, *R. C. McGregor 86,* October 23, 1904 (PUH); grayish deep blue-green growth on sandy soil at Dewey Boulevard, 90, November 12, 1939 (PUH, PNH); blackish growth on stone wall along Pennsylvania street, 108a, November 18, 1938 (PUH); all from UP Botanical Garden: growing with *Scytonema* and *Aphanothece* spp. on walls, 468, March 18, 1940 (PUH); yellowish-green growth on sides of tank, 574, November 26, 1940 (PUH); dark blue-green growth on cemented walls of aquarium, 591, January 11, 1941 (PUH); floating with *Aphanothece* sp. (Sprengel) A. Br. as a dark blue-green mass in a street canal at Singalong Subdivision, 260, January 3, 1940 (PUH); in Pandacan: light greenish-blue growth on old stone wall of church, 566, August 10, 1940 (PUH) and growing in a rice field, 572, August 10, 1940 (PUH); Pasay City: Dry yellowish-brown growth on walls along roadside, 3779, March 9, 1956 (PUH, PNH); Quezon City: dark blue-green growth on very moist side of small creek, Kamuning, 2538, August 19, 1950 (PUH, PNH, FC); dark blue-green growth on surface of water in a small creek at Kamuning, 2540, August 19, 1950 (PUH, PNH, FC); dull blue-green growth on moist soil along roadside at La Mesa Park, Novaliches, 3726, January 27, 1956 (PUH, PNH); blackish growth on standing water in rice field along Broadway street, 178, December 13, 1939 (PUH, PNH); on UP Campus: blackish blue-green growth on very moist embankment of adobe stones, 2454, July 28, 1950 (PUH, PNH, FC): on moist exposed elevated ground at North Avenue, 2425, July 22, 1950 (PUH, PNH).

COCCOCHLORIS PENIOCYSTIS Drouet and Daily. **Plate 1, fig. 3.**

C. Peniocystis DROUET and DAILY, Lloydia 11 (1948) 78.

Cells solitary or in colonies with lamellated, gelatinous matrices, generally yellowish blue-green, conspicuously cylindrical, 1 to 3 μ wide, with length several times the width, usually straight, at times slightly curved, truncate at both ends; protoplasm homogeneous.

Solitary cells exhibit Brownian movement. Also, they can easily be taken for large growth of bacteria.

Single specimen examined.—LUZON: Laguna: dark blue-green growth in hot spring at Talakay, Los Baños, 2462, August 8, 1948 (PUH, PNH).

Genus ANACYSTIS Meneghini, 1837

Plants microscopic to macroscopic; spherical cells divide in three planes at right angles to each other, finally distributed without order in gelatinous, sometimes very tough, matrices.

1. Matured cells with large conspicuous pseudo-vacuoles, developing as water blooms .... *A. cyanea*
1. Matured cells without pseudo-vacuoles, never developing as water blooms 2
    2. Matured cells 0.5 to 1.5 μ wide .... *A. marina*
    2. Cells wider 3
3. Cells 2 to 6 micra wide, gelatinous matrix becoming red, yellow and brown .... *A. montana* f. *montana*
3. Cells 6 μ wide to much wider, gelatinous matrix hyaline 4
    4. Cells 23 to 28 μ wide, generally angular after division. *A. dimidiata*
    4. Cells smaller, generally spherical after division 5
5. Plants marine .... *A. æruginosa*
5. Plants fresh water .... *A. thermalis* f. *thermalis*

ANACYSTIS CYANEA Drouet and Daily. **Plate 1, fig. 4.**

A. cyanea DROUET and DAILY, Butler Univ. Bot. Stud. 10 (1952) 221.

Colonies generally more bluish than green; cells clathrate with no order of arrangement, average diameter (3–) 2 to 5

(–7) μ; pseudo-vacuoles present conspicuously in many specimens.

Occurs in many plankton hauls of fresh-water lakes and ponds, abundantly developing as fresh-water blooms in many slow flowing or stagnant rivers and ponds during warm dry months.

Specimens examined. — LUZON: Laguna, forming water blooms formerly known as *Microcystis aeruginosa* at Laguna Bay, *G. T. Velasquez* and *R. Medina 375*, January 15, 1940 (PUH); Rizal: dull blue-green growth floating on and near surface of Pasig River, *W. R. Shaw 347*, March, 1909 (PUH, NY); Manila: yellow-green growth known as *Clathrocystis aeruginosa*, E. Quisumbing, Acc. No. 389939, 1928 (PUH, UC).

ANACYSTIS MARINA Drouet and Daily.

A. marina DROUET and DAILY, Lloydia 11 (1948) 77.

Plant mass rusty blue-green; cells after division depressed subspherical, later becoming spherical to ovoid-cylindrical, 0.5 to 1.5 (–2) μ wide.

Solitary cells exhibit Brownian movement as in *C. Peniocystis.* This is the smallest coccoid form seen of Philippine materials.

Single specimen examined.—PANAY: Iloilo City: growing on moist exterior wall below a leaking pipe at the Iloilo Normal School Building, La Paz, JDS, 1559, January 9, 1953 (PUH, PNH, FC).

ANACYSTIS MONTANA fo. MONTANA Drouet and Daily. Plate 1, fig. 5.

A. montana fo. *montana* DROUET and DAILY, Butler Univ. Bot. Stud. 12 (1956) 45.

Plant mass blue-green, gelatinous, of different shades of color, growing among other algæ; sheaths bright blue-green, at first hyaline, becoming lamellose; cells after division depressed and subspherical, finally becoming round, 2 to 6 μ in diameter.

Generally found in seepage and habitats frequented by rain and exhibits changes of color due to frequent desiccation and subsequent light exposure.

Specimens examined.—LUZON: Ilocos Norte: blackish growth on old brick wall of church in Sarrat, 2247, June 7, 1950 (PUH, PNH). PANAY: Iloilo: blackish growth on old mossy walls of a ruined building south of town plaza in Passi, *JDS 1073*, July 30, 1953 (PUH, PNH). MINDORO: Oriental

Mindoro: all in Puerto Galera: dark brownish growth on trunk of coconut tree at Small Tabinay, 737, April 7, 1941 (PUH, PNH); dull blue-green growth in hot spring of 65° to 75°C at Bisayaan, 1039, April 26, 1941 (PUH, PNH); dull grayish blue-green growth with sterile *Spirogyra*, *Pithophora œdogonia*, *Rhizoclonium hieroglyphicum*, etc. in Big Balatero, 7, April 15, 1953 (PUH, PNH). LUZON: Rizal: dark blue-green growth cultivated at Experimental Station, Division of Fisheries, Dagat-dagatan, Navotas, 628, January, 1941 (PUH); very dull blue-green growth on walls of aeration tank at the Marikina Ice Plant, JDS, 898, April 27, 1952 (PUH, PNH); blackish growth on cliff at Montalban, 3741, February 11, 1956 (PUH, PNH); Manila: all in UP Botanical Garden: dull blue-green growth on stone walls of aquarium, 444, February 21, 1940 (PUH, PNH), thin blackish growth on cemented walls, 445, February 21, 1940 (PUH); and dark blue-green growth on cemented walls of aquarium, 591, January 11, 1941 (PUH).

ANACYSTIS DIMIDIATA Drouet and Daily. Plate 1, fig. 6.

A. dimidiata DROUET and DAILY, Butler Univ. Bot. Stud. 10 (1952) 221.

Plants mostly bright blue-green, usually mixed with other algæ; cells after division truncate, hemispherical, (12–) 23 to 28 (–50) μ wide, enclosed in very firm gelatinous matrix; protoplasm granular.

This species is easily seen even in ordinary examination of plankton organisms because of its remarkably big size.

Specimens examined.—LUZON: Ilocos Norte: yellowish-green mucilaginous growth on side of electric plant in Laoag, 3610, April 18, 1955 (PUH, PNH); Ilocos Sur: dark blue-green growth on muddy bank of roadside in Narvacan, 3645, April 17, 1955 (PUH, PNH). MINDORO: Oriental Mindoro: in Puerto Galera: pale blue-green growth along side of embankment of stream at San Isidro, 952, April 23, 1941 (PUH, PNH), growing at Big Balatero, 10, May 6, 1953 (PUH), in the yard of Mr. Vicente at Jolo, Sulu Province, May 22, 1952 (FC, PUH, PNH).

ANACYSTIS AERUGINOSA Drouet and Daily. Plate 1, fig. 7.

A. æruginosa DROUET and DAILY, Lloydia 1 (1948) 77.

Plants very pale blue-green, generally decolorized; cells after division depressed or subspherical, (6–) 6.8 to 15.8 (–12) μ, become globose and arranged without order in a hyaline, gelatinous, indistinctly lamellose sheath; protoplasm pale blue-green, very finely to generally homogeneous.

This species had been collected so far locally in salt water only.

Specimens examined.—MINDORO: Oriental Mindoro: light green growth at Tangalan Cove, 1671, May 5, 1948 (PUH, PNH, FC); yellowish dark blue-green growth at Small Balatero Cove, 1880, May 11, 1949 (PUH, PNH, FC); McGregor, no number, October 25, 1925 (PUH, FC).

ANACYSTIS THERMALIS fo. THERMALIS Drouet and Daily. **Plate 1, fig. 8.**

A. thermalis fo. *thermalis* DROUET and DAILY, Butler Univ. Bot. Stud. 12 (1956) 77.

Plants usually blue-green, at times pinkish to violaceous: cells in division depressed and subspherical, later becoming globose, generally (6–) 5.0 to 8.5 (–12) μ wide, arranged in any order in eucapsoid series numbering up to eight, distributed in hyaline usually lamellose sheaths, others becoming somewhat diffluent; protoplasm granular, pale blue-green, olive or rose-violet.

Specimens examined.—PANAY: Iloilo: very dark blue-green growth on moist sides of kiosko in the town plaza of Cabatuan, *JDS 1112*, November 16, 1952 (PUH, PNH). LEYTE: dark blue-green masses floating on shallow water of swamp at airstrip near Tacloban, *M. E. Britton 83*, July 4, 1945 (PUH, FC); yellow to olive-green layer on sandy bottom of small pool at airstrip near Tacloban, *M. E. Britton 80*, July 4, 1945 (PUH, FC). LUZON: Rizal: grayish blue-green growth on walls of æration tank of the Marikina Ice Plant, *JDS 897*, April 27, 1952 (PUH, PNH); grayish blue-green growth on Montalban cliff, 3842, February 11, 1956 (PUH, PNH).

Genus ENTOPHYSALIS Kutzing, 1843

Plants microscopic, when young with spherical cells which become cylindric or polyhedral, on maturity forming cushion shapes, narrow or extended strata and usually forming endospores of various shapes and sizes. This group of plants are abundant in aquatic habitat.

Key to the species of Entophysalis

1. Plants marine, epiphytic or endophytic, generally forming endospores. *E. conferta*
1. Plants fresh water, epiphytic, generally remaining vegetative. *E. Lemaniæ* fo. *Lemaniæ*

ENTOPHYSALIS CONFERTA Drouet and Daily. Plate 1, fig. 9.

E. conferta DROUET and DAILY, Lloydia 11 (1948) 79.

Plants epiphytic, microscopic to macroscopic, at first unicellular, spherical or ovoid, soon developing into cushion shapes which measure up to 20 μ in width; spherical cells usually 3 to 6 μ in diameter, contents generally blue-green becoming variously colored.

Occurs generally as epiphytes in *Lyngbya æstuarii* and *Chætomorpha brachygona* in brackish-water fishponds.

Specimens observed.—LUZON: Rizal: cultivated in fishponds at Dagat-dagatan, 624, January 19, 1941 (PUH, PNH, FC); growing on *L. æstuarii* at Parañaque, *M. T. Cruz 19555,* August, 1933 (PUH, PNH, FC); growing on *L. ætuarii* in brackish-water fishponds, *E. D. Merrill 7458,* January, 1911 (PUH).

ENTOPHYSALIS LEMANIAE fo. LEMANIAE Drouet and Daily. Plate 1, fig. 10.

E. Lemaniæ fo. *Lemaniæ* DROUET and DAILY, Butler Univ. Bot. Stud. 12 (1956) 127.

Solitary cells at first spherical, later becoming ovoid to cylindrical, forming epiphytic cushions of blue-green to purplish colorations.

The two collections were growing epiphytically on *Plectonema Wollei.*

Specimens observed.—LUZON: Laguna: growing on stones submerged in water of swimming pool at Pansol, Calamba, 464, February 25, 1940 (PUH, PNH, FC). MINDORO: Oriental Mindoro: on *P. Wollei,* waterfall at Bisayaan, Puerto Galera, 1518, April 12, 1948 (PUH, PNH, FC).

Genus STICHOSIPHON Geitler, 1931

Plants generally microscopic, epiphytic on other algæ; young solitary cells spherical, finally becoming elongate and attached as erect and variously curved pseudo-filaments.

STICHOSIPHON SANSIBARICUS Drouet and Daily. Plate 1, fig. 11.

S. sansibaricus DROUET and DAILY, Butler Univ. Bot. Stud. 10 (1952) 223.

Plants at first unicellular, then stipitate, finally growing as short filaments; at first in a closed sheath which finally opens and becomes variously curved; filaments blue-green to violet in color (3 to 7) 6.8 μ wide on the average and up to (400) 91.8 μ long as observed in only one Philippine collection; uniseriately arranged cells enclosed in a thin sheath; protoplasm very finely granular or homogeneous.

Specimens examined.—LUZON: Laguna: growing with *Chamæsiphon filamentosa* in rice fields at Los Baños, *E. Quisumbing 77295*, October 13, 1929 (PUH, PNH, UC), on *Cladophora* in little spring at base of Igkaras Hill, Alimodian, Iloilo, *JDS 1538*, December 7, 1952 (PUH, FC).

Order HORMOGONALES

The two sub-orders of this big group of filamentous blue-green algæ are the Homocystineæ and the Heterocystineæ. The former is represented by simple rarely branching filaments with trichomes composed of cells developed without differentiation along the entire length except at their ends, while the latter is composed of filaments which usually branch, with cell arrangement in the trichomes interrupted by the development of heterocysts and akinetes. These structures are quite important as taxonomic characters.

Reproduction is by transverse fission of cells in the filaments which causes the increase in length of the trichomes usually followed by hormogones produced generally by the death of cells in the trichomes of the Homocystineæ, or by breaking usually at the heterocysts in the trichomes of the Heterocystineæ. Akinetes are formed as an advanced method of asexual reproduction in certain families and many genera of the latter order.

Key to the families

1. Filaments with trichomes consisting of uniform cells throughout due to absence of heterocysts .... *Oscillatoriaceæ*
1. Filaments with trichomes consisting of cells not uniform throughout due to interruption of heterocysts 2
  2. Filaments with delicate sheaths, mostly confluent, not readily visible .... *Nostocaceæ*
  2. Filaments with developed sheaths, generally thick and conspicuous 3
3. Filaments tapering from base to tip, ending into a colorless hair, with basal heterocysts .... Rivulariaceæ
3. Filaments not tapering, heterocysts intercalary 4
  4. Filaments developing false branches .... Scytonemataceæ
  4. Filaments developing true branches .... Stigonemataceæ

Family OSCILLATORIACEÆ

The members of this family have trichomes consisting of a row of uniformly developed cells without differentiation except towards their tips. The sliding, screwy, or usually oscillating movements of many usually common representatives justify this important characteristic of the family. Reproduction is by transverse fission of the individual cells in the trichomes and by fragmentation of filaments into hormogones that grow as young plants.

Key to the genera

1. Sheaths not visible 2
1. Sheaths visible 3
  2. Trichomes spiral .... *Spirulina*
  2. Trichomes straight .... *Oscillatoria*
3. Sheaths thin, never striated 4
3. Sheaths thick, generally striated 5
3. Sheaths enclosing several to many trichomes 6
  4. Trichomes oftentimes agglutinated by their mucous sheath. *Phormidium*
  4. Trichomes free, usually forming erect tufts .... *Symploca*
5. Generally free-floating, forming fragile oftentimes matted growth. *Lyngbya*
5. Generally subærial, forming tough woolly growth .... *Porphyrosiphon*
  6. Sheaths solid, closed at tip, trichomes densely arranged. *Schizothrix*
  6. Sheaths open at tip, trichomes loosely arranged .... *Microcoleus*
  6. Sheaths tubular, oftentimes ragged and deformed, with several slightly twisted trichomes .... *Hydrocoleum*

Genus SPIRULINA Turpin, 1827

Members unicellular and without sheaths, forming regular, more or less loose or very close spirals, not tapering at their apices; protoplasmic contents usually homogeneous, sometimes finely granular.

Key to the species of Spirulina

1. Turns of spirals not close together 2
1. Turns of spirals close together 3
  2. Trichomes 1.2 to 1.7 μ wide, regular spirals 2.5 to 4 μ wide, distance between spirals 2.7 to 5 μ .... *S. major*
  2. Trichomes 4.5 to 5 μ wide, regular spirals 11 to 12 μ wide, distance between spirals 9.5 to 11 μ .... *S. princeps*
3. Trichomes 1 to 2 μ wide, regular spirals 3 to 5 μ wide, turns of spirals very close .... *S. subsalsa*

SPIRULINA MAJOR Kutzing. **Plate 1, fig. 12.**

S. major KÜTZING, Phycolog. Genera (1843) 183.

Plant mass floating or on moist surface, scattered among other algæ; trichomes slightly flexuous, blackish-green to bright blue-green. (1.2) 1 to 2 (–1.7) μ wide, regularly spiralled or twisted; regular spiral (2.7–) 2.5 to 4 (–5) μ wide, distance between spirals 2.7 to 5 μ.

Single specimen examined.—LEYTE: forming dark blue-green gelatinous masses with *Oscillatoria sancta,* etc. on submerged sticks in ditch near Laman, *M. E. Britton 120,* August 3, 1945 (PUH, PNH, FC).

SPIRULINA PRINCEPS W. and G. S. West.

S. princeps W. and G. S. WEST, Trans. Linn. Soc. Bot. 6 (1902) 205.

Plant mass thin, blackish to dark blue-green, scattered among other algæ; trichomes short, 4.5 to 5 μ wide, bright blue-green, regularly spiralled; spirals generally loose, 11 to 12 μ wide; distance between spirals 9.5 to 11 μ.

Single specimen examined.—LUZON: Sorsogon: growing on bark, Irosin (Mt. Bulusan). *A. D. E. Elmer 16603,* July, 1916 (PUH).

SPIRULINA SUBSALSA Oersted. Plate 1, fig. 13.

S. subsalsa OERSTED, Beretning om en Excursion til Tridelen, en Alluwialdannelse i Odensefjord, in Natural Tidskrift 7 (1842) 17, fig. 4.

Plant mass deep blue-green, found among other algæ; trichomes 1 to 2 μ wide, pale to bright blue-green, forming regular to mostly irregular spirals, rarely regularly spiralled; spirals 3 to 5 μ in diameter, contiguous to each other.

Specimens examined.—PANAY: Iloilo: deep blue-green growth on mud in front of No. 417, Tanza street, Iloilo City, JDS, October 12, 1952 (PUH, PNH, FC). MINDORO: Oriental Mindoro: yellowish-green growth in small pond at Big Tabinay, Puerto Galera, 926, April 7, 1941 (PUH, PNH). LUZON: Rizal: dark blue-green growth floating with *Oscillatoria salinarum* on fishponds at Dagat-dagatan, Navotas, 620, January 19, 1941 (PUH, PNH).

Genus OSCILLATORIA Vaucher, 1803

Filaments with no visible sheaths, oftentimes crowded and entangled, forming expanded slimy layers developing abundantly in favorably submerged habitats: solitary trichomes cylindrical under the microscope, exhibiting sliding and spiral motility, those with marked polarity especially from an abundant growth show evidence of oscillatory movement which is the natural characteristic of the genus.

Key to the species of Oscillatoria

1. Trichomes large, always from 10 μ to wider 2
1. Trichomes small, never 10 μ wide 12
2. Transverse walls not granulated 3
2. Transverse walls granulated 6
3. Fresh water 4
3. Salt water 5
4. Width of trichomes 16 to 60 μ .... *O. princeps*
4. Width of trichomes 12 to 15 μ .... *O. proboscidea*
5. Width of trichomes 18 to 36 μ .... *O. Bonnemaisonii*
5. Width of trichomes up to 10 μ (in part) .... *O. Corallinæ*
6. Fresh water 7
6. Salt water 11
7 Trichomes somewhat flexuous, not fragile, interrupted by inflated refringent cells .... *O. ornata*
7. Trichomes straight, fragile, not interrupted by inflated refringent cells 8
8. Tapering gradually towards apices, hooked, or curved. *O. chalybea*
8. Not tapering gradually towards apices, not hooked, generally straight 9
9. Width of trichomes 4 to 10 μ (in part) .... *O. tenuis*
9. Width of trichomes much greater 10
10. Cell joints markedly constricted, end cell with a much thickened convex calyptra .... *O. sancta*
10. Cell joints not constricted, end cell with a slightly thickened convex outer wall .... *O. limosa*
11. Width of trichomes 17 to 29 μ .... *O. margaritifera*
11. Width of trichomes 7 to 11 μ (in part) .... *O. nigro-viridis*
12. Cell joints of trichomes much constricted 13
12. Cell joints of trichomes not constricted 20
13. Trichomes flexuous, not fragile 14
13. Trichomes somewhat straight, fragile 17
14. Salt water 15
14. Not salt water 16
15. Width of trichomes 4 μ .... *O. salinarum*
15. Width of trichomes 6 to 10 μ (in part) .... *O. Corallinæ*
16. Width of trichomes 4 to 6 μ .... *O. formosa*
16. Width of trichomes 2.5 to 5 μ .... *O. amœna*
17. Apical cell rotund 18
17. Apical cell obtuse, pointed 19
18. Width of trichomes 2.3 to 4 μ .... *O. geminata*
18. Width of trichomes 4 to 10 μ (in part) .... *O. tenuis*
19. Width of trichomes 3 to 5 μ .... *O. acuminata*
19. Width of trichomes 5.5 to 9 μ .... *O. Okeni*
20. Trichomes interrupted by inflated refringent cells 21
20. Trichomes not interrupted by inflated refringent cells 22
21. Transverse walls granulated, 6 to 8 μ wide .... *O. anguina*
21. Transverse walls not granulated, 4 to 6.5 μ wide .... *O. brevis*

22. Trichomes undulated, loosely spiralled or curved 23

22. Trichomes straight, generally flexuous 25

23. Trichomes 2.4 to 2.6 μ wide .... *O. Willei*

23. Trichomes wider 24

24. Trichomes usually short, irregularly curved, 3.7 to 5.6 μ wide. *O. Grunowiana*

24. Trichomes at first straight, long, later somewhat loosely spiralled to gently curving towards apex, 4 to 6.5 μ wide. *O. terebriformis*

25. Trichomes tapering, end cells hooked, pointed or capitate 26

25. Trichomes not tapering, end cells rotund or slightly conical 27

26. Gradually tapering into a much inflated capitate end cell. *O. splendida*

26. Sharply tapering into a hooked or pointed end cell .. *O. animalis*

27. Cells generally quadrate 28

27. Cells not generally quadrate 29

28. Width of trichomes 2.8 to 3.2 μ, not granulated at cross-walls. *O. articulata*

28. Width of trichomes 3.4 to 3.8 μ, conspicuously granulated at cross-walls .... *O. granulata*

29. Width of trichomes 2 to 3μ, transverse walls usually marked by two protoplasmic granules .... *O. amphibia*

92. Width of trichomes 3.5 to 4 μ, transverse walls not at all granulated. *O. chlorina*

OSCILLATORIA PRINCEPS Vaucher. Plate 1, fig. 14.

O. princeps VAUCHER, Historie des Conferves d'eau douce (1803) 190, pl. 15, fig. 2.

Plant mass blackish to dark blue-green in luxuriant growth; trichomes largest of all species and visible to naked eye, generally bright blue-green to rust-green, at times growing in thick pure culture, straight or slightly flexuous, rigid, fragile when dried, (16–) 20 to 55 (–60) μ wide, tapering softly towards the end with distinctly subcapitate or truncate end cells; ordinary cells very narrow, 3.5 to 7 μ long, cross-walls not constricted, not granulated; protoplasm finely granulated, somewhat coarse in other specimens; end cell gradually or abruptly arched, with or without a smooth membranaceous headlike structure, without calyptra.

Specimens examined. — PANAY: Iloilo: deep blue-green growth floating on canal along San Agustin street, Cabatuan, JDS, 1115, November 16, 1952 (PUH, PNH, FC). LUZON: Laguna: dark blue-green growth at Los Baños, 2477, August 14, 1948 (PUH, PNH, FC). LEYTE: yellowish-green gelatinous masses floating in roadway rut one mile west of Palo, *M. E. Britton, 174,* November 26, 1945 (PUH, PNH, FC);

yellowish blue-green growth in shallow depressions near Tacloban airstrip which floated from soil surface in recent rains, *M. E. Britton 152,* October 10, 1945 (PUH, PNH, FC); forms dark blue-green growth with *Gloeocapsa membranina* and floatting in shallow water of swamp at airstrip near Tacloban, *M. E. Britton 83,* July 4, 1945 (PUH, PNH, FC); deep blue-green growth floating in shallow pond near Tacloban airstrip, *M. E. Britton 151,* October 10, 1945 (PUH, PNH, UC, FC). MINDORO: Oriental Mindoro: dark blue-green growth on very moist surface along a small pool at a stream, San Isidro, Puerto Galera, 959, April 23, 1941 (PUH, PNH, FC). PALAWAN: blackish blue-green growth in Iwahig Penal Colony, 2872, June 18, 1951 (PUH, PNH, FC). LUZON: Pampanga: Blackish blue-green growth on wet fine sandy soil along the highway to Nursery, Arayat, 120, November 19, 1939 (PUH). Manila: very dark blue-green growth floating on drying side of canal near Normal School, 150, November 29, 1939 (PUH, PNH, FC); light to dark blue-green growth on very wet mud at estero, Oregon street, Paco, 142, November 22, 1939 (PUH, PNH).

OSCILLATORIA PROBOSCIDEA Gomont. Plate 1, fig. 15.

O. proboscidea GOMONT, Monogr. Oscill. (1893) 209, pl. 6, figs. 10, 11.

Plant mass blackish, rich blue-green to pale blue-green; trichomes more or less straight, bright blue-green, slightly flexuous, 12 to 15 μ wide, evidently attenuate towards apex; cell contents uniformly finely granulated, cross-walls not constricted, not granulated; end cell curved into a hooklike form or twisted into a distinctly thickened membranous calyptra.

Specimens examined.—LUZON: Bataan: blackish growth in Balanga, 2407, July 12, 1950 (PUH, PNH). PANAY: Capiz: deep blue-green growth on mud behind store in front of municipal building in Ivisan, JDS, 1513, November 30, 1952 (PUH, PNH, FC). LEYTE: dull blue-green growth floating in shaded nipa swamp near Sta. Fe, *M. E. Britton 135,* October 7, 1945 (PUH, PNH, FC); dark blue-green plant mass floating in fresh-water swamp north of Palo, *M. E. Britton 162,* November 23, 1945 (PUH, PNH, FC). MINDORO: Oriental Mindoro: dark blue-green growth on surface of standing water in poblacion of Puerto Galera, 1137, May 9, 1941 (PUH, PNH). PALAWAN: forming thick black growth with other algæ in Cuyo, 2819, June 11, 1951 (PUH, PNH, FC). LUZON: Rizal: deep blue-green growth floating on street canal in front of No. 247 Manuel A. Roxas street, Marikina, JDS, 997, June 3, 1952 (PUH, PNH, FC).

OSCILLATORIA BONNEMAISONII Crouan. Plate 1, fig. 16.

O. Bonnemaisonii CROUAN in Desmazieres, Plant. Crypt. France (537) 11 (1858).

Plant mass blue-green, often ash-colored when growing among other algæ; trichomes loosely spiralled or twisted, 18 to 36 μ wide, long and flexuous, easily deformed on drying; cross-wall constricted, transverse wall not granular, cell contents very finely granular, apical cell gently ending into a convex smooth outer wall, not attenuate, without calyptra.

Single specimen examined.—MINDORO: Oriental Mindoro: yellowish-brown deep blue-green growth on *Hydroclathrus cancellatus* in West Muelle, Puerto Galera, 1854, April 25, 1949 (PUH, PNH, FC, NY, UC).

OSCILLATORIA CORALLINAE Gomont. Plate 1, fig. 17.

O. Corallinæ GOMONT in Morot, Jour. Bot. 4 (1890) 456 (pro parte).

Stratum very thin, somewhat dull dark blue-green; trichomes gregarious, 6 to 10 μ wide, very much elongated, flexuous, somewhat fragile when dry; short cells constricted at joints; protoplasmic contents granular, brownish to pale blue-green; apex gradually tapering, apical cell capitate.

Specimens examined. — LUZON: Bataan: light blue-green growth on a coralline alga in about one-meter water depth at low tide in Lanao, *W. R. Shaw 1170*, May 31, 1911 (PUH, PNH, NY). MINDANAO: Zamboanga: little Sta. Cruz Island in Basilan Strait, 5 miles southwest of Zamboanga, *H. H. Bartlett 16135*, September 19, 1935 (PUH, FC).

OSCILLATORIA ORNATA Kutzing. Plate 1, fig. 18.

O. ornata KÜTZING, Tab. Phycolog. 50 (1845–49) 30, pl. 42, fig. 9.

Plant mass dark blue-green, pink in other specimens; trichomes bright blue-green, 9 to 11 μ wide, very slightly constricted at cell joints, torulose, strongly contorted, gradually tapering; cells distinct, here and there inflated colorless cells interrupting; transverse walls usually granulated, protoplasm finely granular; apical cell rotund, not capitate.

Specimens examined. — MINDORO: Oriental Mindoro: dark blue-green growth in Big Balatero Stream at Puerto Galera, 1700, May 14, 1948 (PUH, PNH, FC). LUZON: Manila: blackish growth floating on street canal at Vito Cruz Subdivision, 551, August 24, 1940 (PUH, PNH, FC).

OSCILLATORIA CHALYBEA Mertens. Plate 1, fig. 19.

O. chalybea MERTENS in Jurgens, Alg. Aquat. (4) 13 (1822).

Plants generally dark green, blue-green to violet blue-green; trichomes straight, 8 to 13 μ wide, dark to light blue-green, sometimes pale bluish-violet, fragile, gently bent, tapering towards the tip; cells rectangular, 3.6 to 8 μ long, cross-walls slightly constricted; protoplasm finely granular becoming transparent towards the transverse walls; end cell obtuse and usually curved, not capitate.

Specimens examined.—PANAY: Iloilo: blackish blue-green growth floating on standing water in canal along General Luna street, *JDS 1001,* June 20, 1952 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: dull yellowish blue-green growth on surface of street canal at poblacion, 715, March 30, 1941 (PUH, FC); deep blue-green growth, 1678, April 19, 1948 (PUH, PNH, FC); dark blue-green growth, in Big Balatero, 1702, May 14, 1948 (PUH, PNH, FC); bluish-greenish black growth floating on canal, 1846, April 22, 1949 (PUH, PNH, FC, NY). PALAWAN: blackish blue-green growth in Araceli, 2926, June 15, 1951 (PUH, PNH). LUZON: Rizal: blackish blue-green growth floating on street canal in front of No. 165, Pasig-Marikina road at Bo. Calumpang, Marikina, JDS, May 10, 1952 (PUH, PNH, FC); Quezon City: in Balara: olive-green to blackish growth, 2508, February 26, 1950 (PUH, PNH, FC); light to dark blue-green growth, 2513, February 26, 1950 (PUH, PNH; on UP Campus: deep to blackish blue-green growth with *Phormidium minnesotense.* 2497, February 12, 1950 (PUH, PNH, FC, NY); blackish blue-green growth, 2514, February 28, 1950 (PUH, PNH).

OSCILLATORIA TENUIS Agardh. Plate 1, fig. 20.

O. tenuis AGARDH, Alg. Dec. Sec. (1813) 25.

Plant mass thin, on moist surface or floating; trichomes fragile blue-green, sometimes olive-green, 4 to 10 μ wide, somewhat mucilaginous, straight, not tapering towards apex; cross-walls constricted; contents of quadrate cells, granulated, granules especially noticeable as pairs at the transverse walls; end cell convex, more or less hemispherical with little thickening membrane.

Specimens examined. — MINDORO: Bulalacao: blue-green growth, *C. B. Robinson 6704*, March 14 to 24, 1908 (PUH, PNH, NY). LUZON: Laguna: grayish blue-green growth in rice field at Los Baños, E. Quisumbing, October 13, 1929 (PUH, FC); forming light blue-green growth with *Phormidium tenue*, etc. on moist shore of Sampaloc Lake, San Pablo City, 455, February 25, 1940 (PUH). MINDANAO: Lanao: deep blue-green, growth in fresh-water lake, Malabang, Mountain, *Liborio Ela Ebalo 1105*, February 25 to March 30, 1941 (PUH). LEYTE: yellowish-green to blue-green stratum on soil and floating on water surface in ditch at "The Monument" near Tacloban, *M. E. Britton 79*, July 4, 1945 (PUH, PNH, FC); grass-green to blue-green layer on masses of mud floated to surface during heavy rains in swamps one mile west of Palo, *M. E. Britton 130*, September 24, 1945 (PUH, PNH, FC); grass-green to blue-green layer on masses of mud floated to surface during heavy rains in swamp one mile west of Palo, *M. E. Britton 131*, September 24, 1945 (PUH, PNH, FC); thick, gelatinous, almost water clear mass in shallow pool in pasture 2 miles south of Palo, *M. E. Britton* no number, October 7, 1945 (PUH, PNH, FC). LUZON: Mountain Province: deep blue-green growth in fresh-water stream at Panai, Benguet, *R. C. McGregor 16*, June, 1909 (PUH, PNH, UC). MINDORO: Oriental Mindoro: deep blue-green growth in vicinity of Puerto Galera, *H. H. Bartlett 13770*, May 5, 1935 (PUH, FC); very thick, dark blue-green mat floating on street canal near pipe at poblacion, 714, March 30, 1941, (PUH, PNH); dark blue-green to blackish growth floating on street canal at poblacion, 713, March 30, 1941 (PUH, FC); pale blue-green growth on wet soil near the stream at San Isidro, 731, April 2, 1941 (PUH, FC); deep blue-green growth at Bisayaan, 1765, April 12, 1948 (PUH, PNH, FC); blackish blue-green growth at Big Balatero, 1701, May 14, 1948 (PUH, PNH, FC); blackish blue-green growth at Big Balatero, 1703, May 14, 1948 (PUH, PNH, FC); forming yellowish blue-green growth with *O. chalybea* and *O. amphibia*, no number, April 23, 1953 (PUH). PALAWAN: ordinary blue-green growth in Coron, June 3, 1951 (PUH, PNH); deep blue-green growth in Cuyo, 2835, June 12, 1951 (PUH, PNH, FC); dull blue-green growth in Tapun, 2899, June 20, 1951 (PUH, PNH). LUZON: Pampanga: floating as a deep green scum on a small polluted pond in Arayat, 113, November 19, 1939 (PUH, PNH); deep blue-green growth on wet surface near running water at Nursery, Arayat, 121, November 19, 1939 (PUH, PNH); Pangasinan: forming yellowish-green growth with *O. ornata* and floating on a small canal along the wayside at Dagupan, 233, December 30, 1939 (PUH, PNH, FC); deep blue-green growth floating on polluted canal along wayside in Dagupan, 227, December 30, 1939 (PUH, PNH, FC); Rizal: yellowish-green to dark blue-green growth floating on shallow standing water in Mandaluyong, 162, December 10, 1939 (PUH, PNH); Manila: blackish blue-green growth, *W. R. Shaw 1086*, 1907 (PUH, PNH, NY); blackish blue-green growth on moist stone wall along Pennsylvania street, 108, November 18, 1939 (PUH, FC); blackish blue-green growth floating on very polluted stagnant water near estero at Oregon street, 143, November 22, 1939 (PUH, PNH, FC); blackish blue-green growth floating with duckweeds on a street canal in Singalong Subdivision, 263, January 3, 1940 (PUH, PNH, FC); blackish blue-green growth floating on a street canal in Singalong Subdivision, 264, January 3, 1940 (PUH, PNH); forming dark blue to dark blue-green floating abundant growth with *O. limosa* on canal in Singalong Subdivision, 259, January 3, 1940 (PUH, PNH); dark blue-green masses floating on street canals at Vito Cruz Subdivision, 550, August 24, 1940 (PUH, PNH); yellowish blue-green mass growing with grasses in water at Sta. Ana junction, 177, December 13, 1939 (PUH, PNH, FC); deep blue-green growth floating on estero on the left side of Normal Hall, 154, November 29, 1939 (PUH, PNH, FC); on UP campus: deep blue-green growth, 704, March 22, 1941 (PUH); dark blue-green growth on standing water near Coll. of Engineering, 660, November 26, 1940 (PUH); yellowish-green to deep blue-green growth in aquarium of L. C. Clemente, Department of Zoology, 576, October 25, 1940 (PUH, PNH, FC); Quezon City: light to dark blue-green growth, 2499, February 12, 1950 (PUH, PNH, FC, NY); dark blue-green growth, 2525, February 28, 1950 (PUH, PNH).

OSCILLATORIA SANCTA Kutzing. Plate 2, fig. 21.

O. sancta KÜTZING, Tab. Phycolog. 1 (1845–1849) 30, pl. 42, fig. 7.

Plant mass gelatinous, glistening, blackish olive to yellowish-violet green; trichomes straight, 10 to 20 μ wide, much elongate, flexuous or curved, gently or suddenly attenuated towards the tip, fragile, pink-reddish in many specimens, pale blue-green in others; cross-walls distinctly constricted and heavily granulated; end cell hemispherical with a conspicuously thickened membrane.

Specimens examined.—LEYTE: olive to yellowish-green gelatinous masses floating on roadside ditch near Tanuan, *M. E. Britton 119,* August 3, 1945 (PUH, PNH, FC). MINDORO: Oriental Mindoro: forming dull blue-green growth with *O. chalybea, O. amphibia,* and *Pithophora œdogonia* in Big Balatero, April 23, 1953 (PUH, PNH). PALAWAN: dark blue-green to black growth in Cuyo, 2811, June 11, 1951 (PUH, PNH, FC). LUZON: Rizal: blackish growth at backyard of Dr. H. Roxas' house in Marikina, 410, February 2, 1940 (PUH, PNH, FC); Manila: on UP campus: blackish growth on dry soil of Botanical Garden near Chemistry Department, 255, January 3, 1940 (PUH, PNH, FC); blackish growth on moist surface of flower pot in Department of Botany, 448, February 21, 1940 (PUH, PNH, FC); forming blackish growth with *Symploca Muscorum* on very moist surface of flower pot in Botanical Garden, 449, February 21, 1940 (PUH, PNH, FC); blackish deep blue-green growth floating on a street canal in Vito Cruz Subdivision, 423, February 4, 1940 (PUH, PNH, FC); blackish growth floating on ditches and canals at Vito Cruz Subdivision, 557, August 24, 1940 (PUH, PNH, FC).

OSCILLATORIA LIMOSA Agardh. **Plate 2, fig. 22.**

O. limosa AGARDH, Disp. Alg. Suec. (1812) 35.

Plant mass blackish dark blue-green to brown; trichomes more or less straight, (11–) 13 to 16 (–20) μ wide, rigid and fragile, long and flexuous in many specimens; cross-walls not constricted, markedly granulated; apical cell smoothly convex with slightly thickened membrane, not capitate.

Specimens examined.—LEYTE: thin, black and rather tenacious stratum on mud and somewhat thicker floating masses in puddle near San Joaquin, *M. E. Britton 140,* October 7, 1945 (PUH, PNH, FC). LUZON: Pampanga: black growth on constantly wet rocks near pipe at Nursery, Arayat, 517, May 22, 1940 (PUH, FC); Manila: black growth with *Lyngbya nigra* and *Microcoleus* sp. on moist outer wall of water tank in UP Department of Botany, 94, November 13, 1939 (PUH, PNH, FC); dark blue-green growth on very moist grassy flat near estero on Oregon street, 144, November 22, 1939 (PUH, PNH, FC).

OSCILLATORIA MARGARITIFERA Kutzing. Plate 2, fig. 23.

O. margaritifera KÜTZING, Tab. Phycolog. 1 (1845) 31, pl. 43, fig. 10.

Plant mass blackish blue-green to violet-reddish; trichomes broad, long, straight, flexuous, 17 to 29 μ wide, gently attenuate towards apex, ending into a smoothly convex capitate cell; cells 3 to 6 μ in diameter, cross-walls constricted; transverse walls usually with conspicuous pearl-like granules, cell contents finely granular.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: light olive-green growth on side of running stream at Small Tabinay, 932, April 7, 1941 (PUH, PNH, FC); olive-greenish growth along the shore submerged even at lowest tide at Medio Island, 847, April 17, 1941 (PUH, PNH, FC); pale blackish-green growth in Bahia, 1691, May 12, 1948 (PUH, PNH, FC). PALAWAN: brownish olive-green growth in Araceli, 2937, June 15, 1951 (PUH, PNH); brownish growth in Catadman Sound, Cuyo, 2939, June 11, 1951 (PUH, PNH, FC). LUZON: Pangasinan: light yellowish blue-green growth on canal along highway in Dagupan, 232, December 30, 1939 (PUH, PNH, FC). SULU: deep blue-green growth in Lapak Agricultural High School, Siasi, 3236-1, May 21, 1952 (PUH, FC). LUZON: Manila: light yellowish blue-green thick mat floating on polluted canal along the highway at Rizal Avenue Extension, 188a, December 16, 1939 (PUH, PNH, FC).

OSCILLATORIA NIGRO-VIRIDIS Thwaites. Plate 2, fig. 24.

O. nigro-viridis THWAITES in Harvey, Phyc. Brit. (375) (1846–51) 39, pl. 251 A, figs. 1 and 2.

Plant mass very dark or black to blue-green; trichomes flexuous, blue-green to pale light pink, slightly constricted at cell joints, 7 to 11 μ wide, straight, fragile, attenuated towards end; transverse walls granulated, end cell slightly thickened, somewhat capitate.

Specimens examined.—LUZON: Rizal: blackish yellow-green at Camus Fish Farm at Malabon, *H. Rabanal* and *G. T. Velasquez 432*, February 7, 1940 (PUH, PNH, FC); blackish blue-green growth on sandy shore at Dagat-dagatan, Navotas, 619, January 19, 1941 (PUH, PNH, FC).

OSCILLATORIA SALINARUM Collins, Holden, and Setchell. Plate 2, fig. 25.

O. salinarum COLLINS, HOLDEN, and SETCHELL, Phyc. Bor. Am. (1160) 24 (1904).

Plant mass light blue-green; trichomes blue-green, straight, generally 4 μ wide, somewhat flexuous, much constricted at cross-walls, gradually or evidently tapering and hooked or slightly curved towards apex; protoplasm granular along cell wall; end cell without calyptra.

Single specimen examined.—LUZON: Rizal: on polluted canal along the highway at Rizal Avenue Extension, 1882, December 16, 1939 (PUH, PNH, FC).

OSCILLATORIA FORMOSA Bory. Plate 2, fig. 26.

O. formosa BORY, Dict. Class d'hist. Nat. 12 (1827) 474.

Plant mass dark to ordinary blue-green; trichomes generally bright blue-green, straight, elongate and flexible, 5 to 6 μ wide, slightly constricted at cross-walls, tapering or abruptly bending towards end cell; cells almost nearly quadrate, 2.5 to 5 μ long, cross-walls sometimes slightly granulated; end cell truncate, cone-shaped, without calyptra.

Specimen examined.—PANAY: Iloilo: blue-green to blackish blue-green growth on moist soil under a foundation at Passi Elementary School, Passi, 1074, July 20, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish blue-green growth in Los Baños, 2476, August 14, 1948 (PUH, PNH); deep blue-green growth on drifting water at San Pablo City, 684, February 9, 1941 (PUH, FC). LEYTE: grass-green growth with *O. princeps* and hormogones of *L. æstuarii* floating on swamp near beach (probably brackish water) near Palo, M. E. Britton, July 25, 1945 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: dark blue-green growth on surface of standing water at poblacion, 1132, March 9, 1941 (PUH); dark blue-green growth on stones near water pipe along the main street in poblacion, 709, March 30, 1941 (PUH, PNH, FC). PALAWAN: deep blue-green to blackish blue-green growth in Coron 2786, June 3, 1951 (PUH, PNH, FC); in Puerto Princesa: blackish blue-green growth, 2913, June 20, 1951 (PUH, PNH); forming a blue-green growth with *L. æstuarii* Gom., 2918, June 20, 1951 (PUH, PNH, FC). LUZON: Quezon City: light yellowish blue-green growth in Balara, 2486, March 24, 1949 (PUH, PNH).

OSCILLATORIA AMOENA (Kutzing) Gomont.

O. amœna (Kützing) GOMONT, Monogr. Oscill. (1893) 245, pl. 7, fig. 9.

Plant mass light dark; trichomes scattered, straight and elongate, 2.5 to 5.0 μ wide, slightly constricted at cell joints, transverse walls marked with fine granules; apex tapering, hooked and capitate.

OSCILLATORIA GEMINATA Meneghini. Plate 2, fig. 27.

O. geminata MENEGHINI, Consp. Alg. Eugan. 9 (1837).

Plant mass thin, blue-green; trichomes pale blue-green, flexuous and curved, 2.3 to 4 μ wide, markedly constricted and transparent at transverse walls; cells quadrate, protoplasm finely granulated, with one or two refringent granules; apical cell obtuse or rotund not capitate.

Specimens examined.—MINDANAO: Lanao: dark blue-green growth in fresh-water lake at Malabang Mountain, *Liborio Ela Ebalo 1101*, February 26 to March 30, 1941 (PUH). MINDORO: Oriental Mindoro: bright blue-green growth floating on stagnant water in poblacion of Puerto Galera, 711, March 30, 1941 (PUH, FC). LUZON: Manila: forming yellowish blue-green almost dried-up growth with *O. tenuis*, *O. anguina*, *P. uncinatum*, and *S. Muscorum* drifted by current to side of a canal near Normal School, 153, November 29, 1939 (PUH, FC).

OSCILLATORIA ACUMINATA Gomont. Plate 2, fig. 28.

O. acuminata GOMONT, Monogr. Oscill. (1893) 227, pl. 7. fig. 12.

Plant mass usually growing with other algæ, thin, pale blue-green; trichomes straight, 3 to 5 μ wide, somewhat fragile, tapering and acuminate towards the tip, sometimes slightly constricted at cell joints; protoplasm granulated, never capitate.

Single specimen seen.—LEYTE: dark blue-green to almost black thin layer on mud at edge of a brackish nipa swamp about 50 yards from beach at northern city limits of Tacloban, *M. E. Britton 161*, November 23, 1945 (PUH, FC).

OSCILLATORIA OKENI Agardh. Plate 2, fig. 29.

O. okeni AGARDH, Aufzahlung, etc. in Flora 10 (1827) 633.

Plant mass dark blackish blue-green; trichomes long, light blue-green, 5.5 to 9.0 μ wide, flexuous, fragile when dry, constricted at cell joints, gradually tapering towards the tip; cells usually quadrate, rarely three to four times longer than wide, with fine protoplasmic granules; apical cell obtuse-rotund, not thickened.

OSCILLATORIA ANGUINA Bory. Plate 2, fig. 30.

O. anguina BORY, Dict. d'hist. Nat. 12 (1827) 467.

Plant mass sometimes dirty, dark to generally bright blue-green; trichomes bright blue-green, 6 to 8 μ wide, straight or very loosely wavy, at times with swollen cells, without constrictions at cross-walls, attenuated; cells narrow, with granular protoplasm; transverse wall lined with conspicuous coarse granules; end cell rounded, slightly thickened with calyptra.

Specimens examined.—PANAY: Iloilo: deep blue-green growth floating on street canal east of the town plaza in Dingle, *JDS 1090*, October 13, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish blue-green growth on moist rocks in Los Baños, *E. Quisumbing 77322*, October 3, 1929 (PUH, FC); dark blue-green growth on saturated soil near an artesian well at San Pablo City, 681, February 9, 1941 (PUH, FC); dark blue-green growth on moist soil in San Pablo City, 680, February 9, 1941 (PUH, FC); Manila: blackish dark blue-green growth with *O. margaritifera* in moist soil frequently wet by lukewarm water from electric plant, *Bur. Sci. 111*, November 18, 1939 (PUH, PNH, FC); blackish deep blue-green growth on stagnant water on UP campus, 655, August 8, 1940 (PUH, FC.)

OSCILLATORIA BREVIS Kutzing. Plate 2, fig. 31.

O. brevis KÜTZING, Phycolog. gener. (1843) 186.

Plant mass dark to light blue-green; trichomes straight, 4 to 6.5 μ wide, blue-green to bright blue-green in many specimens somewhat fragile, not constricted at cross-walls, briefly attenuated; swollen cells present in many specimens; ordinary cell 1.5 to 3 μ long, protoplasm finely granulated with refringent granules, cross-walls not granulated; end cell rounded-conical, somewhat pointed, without calyptra.

Specimens examined. — PANAY: Iloilo: light blue-green growth in Rizal Elementary School ground, *JDS 1096*, October 12, 1952 (PUH, PNH, FC.) LUZON: dark blue-green growth on moist flat neat students' quarters in Los Baños, 376, January 28, 1940 (PUH, FC); Manila: purplish blue-green to blackish blue-green growth on bank of street canal along Rizal Avenue Extension, 189, December 16, 1939 (PUH, PNH, FC); light blue-green to blackish blue-green growth floating on polluted canal along Rizal Avenue Extension 187, December 16, 1939 (PUH, PNH, FC, NY); blackish growth on flower pot at UP Department of Botany, 157, December 7, 1939 (PUH, PNH, FC); dark blue-green growth floating on water in a lot at Vito Cruz Subdivision, 554, August 24, 1940 (PUH, PNH, FC). MINDORO: Oriental Mindoro: forms light blue-green growth with *O. sancta* and *O. proboscidea* on muddy pond in Big Balatero, 945, April 22, 1941 (PUH, PNH, FC). PALAWAN: dark blue-green growth in Puerto Princesa, 2911, June 20, 1951 (PUH, PNH); light yellowish blue-green growth in Araceli, 2924, June 15, 1951 (PUH, PNH). LUZON: Quezon City: in Balara: greenish-black growth, 2509 (PUH, PNH); dark blue-green growth 2512, February 26, 1950 (PUH, PNH); in Kamuning: greenish-black growth, 2546, August 19, 1950 (PUH, PNH); deep blue-green growth 2485, January 29, 1950 (PUH, PNH, FC, NY); Rizal: dark blue-green growth on drying canal along the highway in New Manila, 150, December 13, 1939, (PUH, FC); blackish blue-green growth on flower pot in Tanay, 437, February 9, 1940 (PUH, FC); forms a blackish blue-green floating mass with *O. tenuis* on a small pond in back part of a kitchen in Marikina, 412, February 2, 1940 (PUH, FC); light greenish-growth on moist soil in Bo. Santolan, Pasig, *JDS 989*, May 30, 1952 (PUH), PNH, FC); yellowish blue-green to blue-green growth on a drying canal along the highway in New Manila, 180, December 13, 1939 (PUH, PNH, FC).

OSCILLATORIA WILLEI Gardner. Plate 2, fig. 32.

O. Willei GARDNER, Mem. New York Bot. Gard. 7 (1927) 36, pl. 7, fig. 67.

Plant mass of indefinite growth, dark blue-green; trichomes flexuous, light blue-green 2.4 to 2.6 μ wide, somewhat wavy, becoming lightly screw form and tapering towards the apices, cross-walls not constricted; cells longer than wide or quadrate; end cell not thickened; protoplasm finely granular.

Single specimen examined.—PANAY: Capiz: floating on water of the spring at the head of the Panay River at the Hangoslob Hills, Dumarao, JDS, 1807, February 8, 1953 (PUH, PNH, FC).

OSCILLATORIA GRUNOWIANA Gomont. Plate 2, fig. 33.

O. Grunowiana GOMONT, Monogr. Oscill. (1893) 235.

Plant mass growing with other algæ, dark to ordinary blue-green trichomes, short, pale blue-green, straight, loosely bent, or curved irregularly (3.5–) 3.7 to 5.6 μ wide, not constricted, sometimes briefly tapering; protoplasm irregularly granulated, end cell rotund and slightly capitate.

Specimens examined.—PALAWAN: dull blue-green growth in Araceli, 2931, June 15, 1951 (PUH, PNH). LUZON: Quezon

City: blackish dark blue-green growth in UP campus, 2498, February 12, 1950 (PUH, PNH, FC, NY).

OSCILLATORIA TEREBRIFORMIS Agardh. Plate 2, fig. 34.

O. terebriformis AGARDH, Aufzahlung, etc. in Flora 10 (1827) 364.

Plant mass rusty (chalybea) to dark blue-green; trichomes bright blue-green, (4–) 4.6 to 5 (–6.5) μ wide, flexuous, loosely and somewhat spirally curved, gradually tapering in some specimens; cell joints pellucid, not constricted; cells quadrate, protoplasm somewhat uniformly granular; end cell round, not capitate.

Single specimen examined.—MINDORO: Oriental Mindoro: forming a dark blue-green growth with *Aphanocapsa Roeseana* in hot spring of 65° to 75°C at Bisayaan, Puerto Galera, 1040, April 26, 1941 (PUH, FC).

OSCILLATORIA SPLENDIDA Greville. Plate 2, figs. 35, 35a, and 35b.

O. splendida GREVILLE, Fl. Edin. (1824) 304.

Plant mass thin, dark to bright blue-green; trichomes forming a sheet, 2 to 3 μ wide, pale to bright blue-green, straight or flexuous, slightly curved, narrow, apex gradually tapering into a somewhat curved ending; transverse walls not constricted, cell contents homogeneous; end cell conspicuously inflated, others smooth convex, somewhat capitate.

Specimens examined.—LUZON: Laguna: deep blue-green growth along the shore of Sampaloc Lake in San Pablo City, 451, February 25, 1940 (PUH, FC); Rizal: deep blue-green growth floating on canal polluted with water coming from the hospital in Mandaluyong, 506, May 12, 1940, (PUH, FC); Manila: in UP Department of Botany: deep blue-green growth on flower pot, 446, February 21, 1940 (PUH, PNH, FC); deep blue-green plant mass abundantly growing on flower pot, 158, December 7, 1939 (PUH, FC).

OSCILLATORIA ANIMALIS Agardh. Plate 2, fig. 36.

O. animalis AGARDH, Aufzahlung, etc. in Flora 10 (1827) 632.

Plant mass thin, dark blue-green; trichomes pale blue-green, 3 to 4 μ wide, narrow, attenuate, without constrictions on cross-walls; cells generally quadrate, the end cell mucronate or tapering into a sharp point; protoplasm finely granulated, conspicuous granules present along the transverse walls.

Single specimen examined.—LUZON: Batangas: forming dark blue-green growth floating abundantly with *Aphanothece stagnina* in rice fields at Lipa, 595, January, 1941 (PUH, FC).

OSCILLATORIA ARTICULATA Gardner. Platt 2, fig. 37.

O. articulata GARDNER, Mem. New York Bot. Gard. 7 (1927) 34, pl. 7, fig. 64.

Plant mass usually growing with other algæ, dark to light blue-green; trichomes straight, not attenuate, somewhat rigid, long generally flexuous, 2.8 to 3.2 μ wide; cells generally quadrate, joints not constricted; apical cell rounded, smooth; protoplasmic granules evident.

Single specimen examined.—LUZON: Laguna: blackish blue-green growth on a flat frequently wet with water from an artesian well in San Pablo City, 452, February 25, 1940 (PUH, PNH, FC).

OSCILLATORIA GRANULATA Gardner. Plate 2, fig. 38.

O. granulata GARDNER, Mem. New York Bot. Gard. 7 (1927) 37, pl. 8, fig. 71.

Plant mass very thin, growing with other algæ, violet to dark blue-green; trichomes straight or undulate, rigid, somewhat fragile, flexuous, 3.4 to 3.8 μ wide, pale violet to pale blue-green, transverse walls not constricted; apex not tapering, apical cell with thickened membrane, generally rounded, not capitate; protoplasm coarsely granular throughout, much crowded at cross-walls.

Single specimen examined.—LUZON: Manila: forming black growth with *O. sancta* on seed beds with *Riccia* in UP Department of Botany, 408, January 31, 1940 (PUH, PNH, FC).

OSCILLATORIA AMPHIBIA Agardh. Plate 2, fig. 39.

O. amphibia AGARDH, Aufzahlung, etc. in Flora 10 (1827) 632.

Plant mass thin, blue-green, submerged; trichomes faint blue-green; slender, more or less straight or loosely curved, flexuous, not constricted at joints; cells 2 to 3 μ wide, not tapering or attenuate; end cell rounded, not capitate; protoplasm homogeneous. In slender specimen cells are much longer than wide, ordinarily quadrate in larger specimens.

Specimens observed.—LUZON: Laguna: deep blue-green abundant growth on rocks along the shallow shores of Sampaloc Lake in San Pablo City, 451a, February 25, 1940 (PUH, FC). LEYTE: light blue-green thin layer on mud at the edge of a nipa swamp about 50 yards from beach at southern limits of Tacloban, *M. E. Britton 161*, November 23, 1945 (PUH, FC); green layer on mud and in water of carabao wallow near Alang-alang, M. E. Britton, August 10, 1945 (PUH, FC). MIN-

DORO: Oriental Mindoro: in Puerto Galera: greenish growth at Big Balatero, April 25, 1953 (PUH, FC); deep blue-green growth floating on surface of pollution at poblacion, 1138, May 9, 1941 (PUH, PNH); dark blue-green growth at Big Balatero, 5, April 15, 1953 (PUH). LUZON: Manila, dark blue-green growth floating on a street canal in Singalong Subdivision, 258, January 3, 1940 (PUH, FC); forming a floating deep blue-green mass with *O. brevis* and *O. tenuis* on a canal along the highway in Rizal Avenue Extension, 188b, December 16, 1939 (PUH, PNH, FC); deep blue-green growth on muddy part of a sidewalk on Pennsylvania Street 105, November 18, 1939 (PUH, FC); blackish deep blue-green growth floating on a street canal in Singalong Subdivision 258, January 3, 1940 (PUH, PNH, FC).

OSCILLATORIA CHLORINA Kutzing. Plate 2, fig. 40.

O. chlorina KÜTZING, Phycolog. gener. (1853) 185.

Stratum thin, dark blue-green; trichomes pale blue-green to yellow-green, 3.5 to 4 μ wide, not constricted at cell joints, slightly flexuous, fragile when dried; cells longer than wide, end cell lightly obtuse with much thickened outside wall; protoplasm finely granular to homogeneous.

Single specimen examined.—LUZON: Bulacan: forming dark blue-green growth with *O. princeps*, *O. tenuis* and *Spirulina major* floating abundantly on canal behind the kitchen at Calumpit, 427, February 4, 1940 (PUH, PNH, FC).

Genus PHORMIDIUM Kutzing, 1843

Filaments simple, unbranched, enclosed within usually very thin conspicuous sheaths, more or less diffluent and agglutinated thus forming feltlike layers covering unlimited surface; trichomes cylindrical, constricted in some species, generally tapering towards the apices, ending into conical and capitate end cells.

Readily distinguished from *Oscillatoria* by its evident sheath which is responsible for the formation of compact woolly layers characteristically holding together in collection. Similar masses of *Oscillatoria* readily break and dissociate easily owing to general absence of sheaths.

Key to the species of Phormidium

1. Trichomes very rarely over 3 μ wide 2
1. Trichomes always 3 μ wide or much wider 11

2. Cell joints slightly or evidently constricted 3
2. Cell joints not constricted 7
3. Evidently constricted 4
3. Slightly constricted 6
4. Marine .... *P. persicinum*
4. Fresh water 5
5. Cells quadrate, protoplasmic contents coarsely granular .. *P. molle*
5. Cells not quadrate, protoplasmic contents homogeneous. *P. minnesotense*
6. End cell acute-conical .... *P. tenue*
6. End cell rotund .... *P. luridum*
7. End cell conical or acute-conical 8
7. End cell rotund, not capitate 9
8. Marine, transverse wall conspicuous .... *P. Crosbyanum*
8. Fresh water, transverse wall not conspicuous owing to refringent granules .... *P. laminosum*
9. Cells regularly subquadrate .... *P. purpurascens*
9. Cells much longer than wide 10
10. Length of cells generally 2 to 2.5 times the width. *P. valderianum*
10. Length of cells up to ten times the width .... *P. treléasei*
11. Cell joints slightly or evidently constricted 12
11. Cell joints not constricted 14
12. Evidently constricted, end cell acute-conical ...... *P. tinctorium*
12. Slightly constricted, end cell rotund or depressed conical ... 13
13. Marine, transverse wall not granulated .... *P. penicillatum*
13. Fresh water, transverse wall rarely granulated .... *P. ambiguum*
14. End cell slightly or markedly capitate 15
14. End cell not capitate 18
15. Cells generally subquadrate 16
15. Cells not generally subquadrate 17
16. Transverse wall not granulated, end cell with a depressed oblique-conical calyptra .... *P. calidum*
16. Transverse wall granulated, end cell with a distinct conical calyptra .... *P. uncinatum*
16. Transverse wall frequently with double rows of granules, end cell with a hemispherical calyptra .... *P. favosum*
17. End cell with a conspicuous rotund calyptra .... *P. autumnale*
17. End cell with a straight conical calyptra .... *P. subfuscum*
18. Trichomes generally large, very slightly tapering into a truncate end cell .... *P. Retzii*
18. Trichomes generally much smaller, briefly tapering into an obtuse conical end cell 19
19. Transverse wall obscured by protoplasmic granules .... *P. inundatum*
19. Transverse wall distinct, not granulated .... *P. papyraceum*

PHORMIDIUM PERSICINUM Gomont. Plate 2, fig. 41.

P. persicinum GOMONT, Monogr. Oscill. (1893) 164.

Plant mass very thin, light blue-green, filaments loosely entangled; trichomes 1.7 to 2 μ wide, loosely interwoven within delicate sheaths, much constricted, lightly tapering towards apex; apical cell conical, without calyptra; protoplasm homogeneous.

Single specimen examined.—MINDORO: Oriental Mindoro: greenish growth on sand submerged along shallow shore of Medio Island, Puerto Galera, 916, April 17, 1941 (PUH, PNH, FC).

PHORMIDIUM MOLLE Gomont. Plate 2, fig. 42.

P. molle GOMONT, Monogr. Oscill. (1893) 163, pl. 4, fig. 12.

Plant mass dark blue-green, enclosed in a gelatinous, diffluent sheath; trichomes blue-green, interwoven, forming agglutinated mat, 2.7 to 3.3 μ wide, constricted at cell joints; cell doliform, apical cell rotund, without calyptra; protoplasm coarsely granular.

Specimens examined. — LUZON: Manila: deep blue-green growth submerged in water at Vito Cruz Subdivision, 556, August 24, 1940 (PUH, PNH, FC); dull blue-green growth with *P. autumnale* floating on canal at premises of Philippine Long Distance Telephone Company, Marquez de Comillas, 585, January 8, 1941 (PUH, PNH, FC).

PHORMIDIUM MINNESOTENSE (Tild.) Drouet. Plate 2, fig. 43.

P. minnesotense (Tild.) DROUET, Field Mus. Nat. Hist. Bot. Ser. 20 (1942) 36.

Plant mass thin, bright to pale blue-green; filaments in transparent sheaths; trichomes bright blue-green, 2 to 3 μ wide, usually straight others variously twisted, wavy, somewhat fragile, constricted at cell joints; cells rectangular, apical cell conical, with calyptra; protoplasm finely granular.

Specimens examined. — LUZON: Laguna: deep blue-green growth with *O. brevis* in Los Baños, 2478, August 24, 1948 (PUH, PNH, FC); Rizal: bright blue-green growth on damp soil at Lopez Jaena street, Bo. Tañong, Marikina, *JDS 961*, May 22, 1952 (PUH, PNH, FC).

PHORMIDIUM TENUE Gomont. Plate 2, fig. 44.

P. tenue GOMONT, Monogr. Oscill. (1893) 169, pl. 4, fig. 23–25.

Plant mass dark blue-green, membranaceous, expanded, usually coarse on surface; filaments much elongated, densely interwoven, sheaths very thin; trichomes pale blue-green, very narrow, 1 to 2 μ wide, fragile in dry specimens, somewhat constricted at cell joints; apical cell acute-conical; protoplasm homogeneous or very finely granular.

Sheaths are usually agglutinated, forming a continuous thin blue-green layer and frequently collected in hot springs.

Specimens examined.—LUZON: Bataan: dull dark blue-green growth in Sta. Rosa, 2410, July 13, 1950 (PUH, PNH, FC). PANAY: Rizal: blackish deep blue-green growth on moist soil beside Evangelical church in Roxas City, JDS, November 30, 1952 (PUH, PNH, FC); Laguna: in Los Baños: pale blue-green growth in hot spring with *Hapalosiphon laminosus*, etc., R. S. Williams, no number, January 6, 1905 (PUH, PNH, FC); blackish deep blue-green growth under dripping water at Silviculture Building, School of Forestry, 575, December 1, 1940 (PUH, PNH, FC). MINDORO: Oriental Mindoro: very pale greenish growth on dry surface of a pond at Small Tabinay, Puerto Galera, 725, April 2, 1941 (PUH, PNH, FC). PALAWAN: blackish deep blue-green growth in 60°C hot spring in Puerto Princesa, 2915a, June 20, 1951 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth on moist soil near a pump well at Bo. Santolan, Pasig, *JDS 905*, May 12, 1952 (PUH, PNH, FC); blackish blue-green growth peeling off from dry stones on side of canal in Mandaluyong, 508, May 12, 1940 (PUH, FC; Manila: dark blue-green growth on moist soil on bank of estero, front of Quezon Elementary School, Tondo, JDS, 563a, November 27, 1939 (PUH, PNH, FC); very dark blue-green growth frequently wet by rain water from a house at Padre Faura Street, 95, November 14, 1939 (PUH, PNH, FC); deep blue-green growth frequently wet with dripping water from a house, Padre Faura Street, 96, November 14, 1939 (PUH, FC); Quezon City: blackish deep blue-green, growth in UP campus, 2428, July 22, 1950 (PUH, PNH, FC).

PHORMIDIUM LURIDUM Gomont. Plate 2, fig. 45.

P. luridum GOMONT, Monogr. Oscill. (1893) 165, pl. 4, figs. 17, 18.

Plant mass thin, blue-green, amethyst-purple; filaments straight and conspicuous: trichomes blue-green, 1.7 to 2 μ wide, variously interwoven, fragile, agglutinated in very narrow sheaths, slightly constricted at cell joints, not tapering; apical cell rotund, without calyptra; protoplasm very finely granular.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: dull dark blue-green growth with *Microcoleus vaginatus* and *Phormidium Crosbyanum* on cement under dripping water at poblacion, 710, March 30, 1941 (PUH, PNH, FC);

very deep blue-green growth on cement base of pipe—source of drinking water in poblacion, 712, March 30, 1941 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth with *M. vaginatus* at back of kitchen in Marikina, 413, February 2, 1940 (PUH, PNH, FC).

PHORMIDIUM CROSBYANUM Tilden. Plate 2, fig. 46.

P. Crosbyanum TILDEN in American Algæ. Century VII (645) 1 (1909).

Plant mass forming blue-green to brownish-red crusts up to 2 cm thick, somewhat tough blue-green agglutinated sheaths; filaments very much entangled or arranged somewhat parallel with each other; trichomes intertwined, very narrow, 1 to 2 μ wide, within delicate sheaths, not constricted at cell joints; cells rectangular, rotund at apex, protoplasm homogeneous or with conspicuous granules.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: tough and leathery, dull olive-green-yellow small "growth" between tides in Boquete, little Balatero, side, *H. H. Bartlett 14034* (PUH, PNH, FC); olive-greenish growth in Lubang, *Herculana S. Villaflores 13*, September 11 to 17, 1935 (PUH, PNH, FC); pale yellowish-green to blue-green growth in Small Balatero, 1704, May 9, 1948 (PUH, PNH, FC, NY); light olive-green to brownish yellow-green growth in East Medio Island, 1869, April 28, 1949 (PUH, PNH, FC, NY).

PHORMIDIUM LAMINOSUM Gomont.

P. laminosum GOMONT, Jour. Bot. 4 (1890) 355.

Plant mass thin, membranaceous, light blue-green; trichomes very thin 1 to 1.3 (1.5) μ wide within a mucous sheath, flexuous, interwoven among other algæ; cells rectangular, cross-walls not constricted nor conspicuous at joints; protoplasm with prominent granules; apex somewhat tapering, ending into a conical cell, not capitate.

Philippine material usually very narrow, generally 1 μ wide.

Single specimen examined.—LUZON: Laguna: greenish to dark blue-green growth on soil being sprayed continuously with water from hot spring in Los Baños, 2529, March 6, 1950 (PUH, PNH, FC, NY).

PHORMIDIUM PURPURASCENS Gomont. Plate 3, fig. 47.

P. purpurascens GOMONT in Morot, Jour. Bot. 4 (1890) 355.

Plant mass compact, leathery to coriaceous, dark blue-green;

trichomes 1.5 to 2.5 μ wide, enclosed in usually diffluent sheaths, flexuous and narrow, much entangled, not constricted at cell joints, not tapering; apical cell rotund, without calyptra; protoplasm not granular, transverse wall lined with protoplasmic granules.

Single specimen examined. — MINDORO: Oriental Mindoro: blackish deep blue-green growth on stones submerged in standing water at poblacion, Puerto Galera, 1133, May 9, 1941 (PUH, PNH).

PHORMIDIUM VALDERIANUM Gomont. Plate 3, fig. 48.

P. valderianum GOMONT, Monogr. Oscill. (1893) 167, pl. 4, fig. 20.

Plant mass dark blue-green, greenish in some specimens, growing up to 2 to 3 mm thick in hot springs; trichomes brilliant blue-green, 2 to 2.5 μ wide, enclosed in narrow sheaths, becoming papery and agglutinated, variously interwoven, oftentimes flexuous, not constricted at cross-walls, not tapering towards the tip; cells longer than wide, each with 2 to 4 conspicuous granules, end cell captiate, rotund.

This alga grows luxuriantly in hot springs.

Specimens examined.—PANAY: Iloilo: dark blue-green extensive growth on moist yard along Mabini street, Arevalo, JDS, July 13, 1952 (PUH, PNH, FC). MINDANAO: Lanao: deep blue-green growth in fresh-water lake at Malabang Mountain, *Liborio Ela Ebalo 1102*, February 26 to March 30, 1941 (PUH). PALAWAN: bright greenish growth in Araceli, 2934, June 15, 1951 (PUH, PNH, FC); blackish blue-green growth in 60°C hot spring in Puerto Princesa, 2915, June 20, 1951 (PUH, PNH, FC, NY). LUZON: Rizal: blue-green growth on moist, damp soil at No. 444 Capt. Sindo street, Bo. J. de la Peña, Marikina, JDS, 969, May 22, 1952 (PUH, PNH, FC).

PHORMIDIUM TRELEASEI Gomont. Plate 3, fig. 49.

P. Treleasei GOMONT, Bull. Soc. Bot. Fr. 46 (1899) 37.

Plant mass expanded, somewhat thick and leathery; filaments parallel, slender and straight; sheaths thin and agglutinated; trichomes 0.6 to 0.8 μ wide, not constricted at cell joints; apex not tapering, rotund, not capitate.

Single specimen examined. — MINDORO: Oriental Mindoro: growing abundantly on moist cell by a hot spring at Naujan Lake, 3937, May 10, 1956 (PUH, PNH, FC).

PHORMIDIUM TINCTORIUM Kutzing.

P. tinctorium KÜTZING, Tab. Phycolog. 1 (1845–1849) 35, pl. 49, fig. 3.

Plant mass somewhat agglutinated and hard, purplish or violet; trichomes 6 to 8.5 μ wide, within delicate sheaths, forming penicillate tufts, suberect, parallel, elongate, somewhat wavy, conspicuously constricted at cell joints; cells barrel-shaped, with light purplish blue-green, finely granular contents; apical cell rotund-conical, without calyptra.

PHORMIDIUM PENICILLATUM Gomont.

P. penicillatum GOMONT, Bull. Soc. Bot. Fr. **40** (1893) 159.

Plant mass arborescent, dark rose to reddish color; trichomes light blue-green, delicate, easily deformed on drying, variously entangled within wide thin sheaths, slightly tapering at the apices, apical cell truncate, not capitate; transverse wall very slightly constricted and lined with paired granules; protoplasm coarsely granular.

Specimens examined.—BABUYAN ISLANDS: yellowish-green growth in Camiguin Island, *R. C. McGregor 123*, July, 1907 (PUH, UC). MINDORO: Oriental Mindoro: in Puerto Galera: olive-green growth with *Symploca læte-viridis* drifting along the shore at Paniquian Island, 842, April 8, 1941 (PUH, PNH, FC); yellowish-green growth with *O. limosa* along the shoreline exposed during low tide at Ensenada, 1042, April 27, 1941 (PUH, PNH).

PHORMIDIUM AMBIGUUM Gomont. **Plate 3, fig. 50.**

P. ambiguum GOMONT, Monogr. Oscill. (1893) 178, pl. 8, fig. 10.

Plant mass dark blue-green, thin, leathery and expanded; trichomes bright blue-green to cuprous blue-green, 4 to 6 μ wide within firm sheaths, variously flexuous, brittle in dried specimens, tapering lightly and slightly constricted at cells quadrâte with distinct transverse walls; protoplasm granulated; end cell rotund, slightly thickened.

Specimens examined.—LUZON: Ilocos Sur: thin greenish coating on soft rock at Narvacan Beach, *Moises M. Kalaw 4*, June 12, 1935 (PUH, FC). PALAWAN: blackish deep blue-green growth with *Glœocapsa alpicola* in Iwahig Penal Colony, 2885, June 8, 1951 (PUH, PNH, FC). LUZON: Rizal: yellowish blue-green growth on wall of aquarium at Fishery Station in Dagat-dagatan, Navotas, 183, December 15, 1939 (PUH, FC, NY); blue-green growth in San Mateo, *JDS 971*, May 27, 1952 (PUH, PNH, FC).

PHORMIDIUM CALIDUM Gomont.

P. calidum GOMONT in Morot, Jour. Bot. 4 (1890) 355.

Plant mass thin, membranaceous, blue-green, sometimes soil dark; trichomes blue-green, 6 to 8 μ wide within very thin hardly visible sheaths, not constricted at joints, somewhat flexuous, slightly tapering; cells rectangular, with granular protoplasm, end cell somewhat bent and depressed, conical and slightly thickened.

PHORMIDIUM UNCINATUM Gomont. Plate 3, fig. 51.

P. uncinatum GOMONT in Morot, Jour. Bot. 4 (1890) 355.

Plant mass widely expanded, dark blue-green, sometimes yellowish; trichomes 6 to 9 μ wide, blue-green variously interwoven, within distinct sheaths, agglutinated, flexuous, some loosely spiralled, not constricted at cell joints, briefly tapering; end cell distinctly capitate, in some oblique and thickened; protoplasmic contents granular.

Specimens examined.—PANAY: Iloilo: rich blue-green growth on sides of concrete dam near water gate at Aganan River Irrigation Project in San Miguel, *JDS 1051*, June 29, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish deep blue-green growth under water in a canal near the students' washroom in Forestry Camp, Los Baños, 379, January 28, 1940 (PUH, PNH, FC). MINDORO: Oriental Mindoro: dark blue-green growth along the side of canal leading from bathroom at campus of Biological Station, Puerto Galera, 1136, May 9, 1941 (PUH.) LUZON: Rizal: blackish growth on surface of other algæ in Mandaluyong, 166, December 10, 1939 (PUH, PNH, FC); Manila: dark blue-green growth drying on side canal at Oregon Street, 145, November 22, 1939 (PUH, PNH, FC).

PHORMIDIUM FAVOSUM Gomont. Plate 3, fig. 52.

P. favosum GOMONT, Monogr. Oscill. (1893) 180, pl. 5, figs. 14, 15.

Plant mass dark to brilliant blue-green; trichomes 4.5 to 9 μ wide, interwoven indefinitely, blue-green to purplish blue-green; cells rectangular, transverse wall clear with conspicuous margaritiferous pair of granules, protoplasm finely granular; apex tapering, apical cell truncate with hemispherical calyptra.

Single specimen examined.—LUZON: Pampanga: submerged in water from an artesian well at Nursery, Arayat, 125, November 19, 1939 (PUH, PNH, FC, NY, UC).

PHORMIDIUM AUTUMNALE Gomont. Plate 3, fig. 53.

P. autumnale GOMONT, Monogr. Oscill. (1893) 187, pl. 5, figs. 23, 25.

Plant mass thin, expanded, dark blue-green; trichomes bright blue-green, 4 to 7 μ wide, enclosed in a very thin mucous sheath, straight, parallel, not constricted at cell joints, fragile when dry, much adhering to form a thin mat; cells quadrate, contents coarsely granulated, apical cell somewhat thickened, briefly curved or straight, rotund.

Specimens examined.—LUZON: Bulacan: yellowish dark blue-green growth on wall of water tank in Calumpit, 425, February 4, 1940 (PUH, PNH, FC). PANAY: Capiz: bright blue-green growth encrusting on damp soil beside house at the switch crossing in Tapaz, *JDS 1127*, November 27, 1952, (PUH, PNH, FC). LUZON: Laguna: in Los Baños: blackish growth on rain water canal beside Students' Mess Hall, Forestry Camp, 383, January 28, 1940 (PUH, PNH, FC); bluish-green growth on a canal frequently wet with water behind kitchen of Students' Mess Hall at Forestry Camp, 392, January 28, 1940 (PUH, PNH, FC). LEYTE: dark blue-green growth floating on shallow waste water pool at south city limit of Tacloban, *M. E. Britton 160*, November 23, 1945 (PUH, PNH, FC). LUZON: Mountain Province: forming blackish dark blue-green with *P. calidum* on dry canal frequently wet with rain water along Leonard Wood road, Baguio, 214, December 28, 1939 (PUH, PNH, FC). MINDORO: Oriental Mindoro: deep blue-green growth on walls of artesian well at Small Tabinay, 724, April 2, 1941 (PUH, PNH, FC). PALAWAN: deep blue-green growth in Aborlan, 2866, June 17, 1951 (PUH, PNH, FC); light blue-green growth in Araceli, 2928, June 15, 1951 (PUH, PNH, FC); blackish deep blue-green growth in Cuyo, 2843, June 9, 1951 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth on moist soil beside a store at the road-crossing at sitio Lamuan, Marikina, JDS, May 20, 1952 (PUH, PNH, FC, NY); Manila: deep blue-green growth along the sidewalk at Pennsylvania Street, 97, November 14, 1939 (PUH, FC); blackish blue-green growth on decaying leaves in a small drying pool of standing water, *Bur. Sci. 429*, February 7, 1940 (PUH, FC); dark blue-green growth on walls of a street canal below the water surface at Vito Cruz Subdivision, 555, August 24, 1940 (PUH, PNH, FC); Quezon City: all in Balara: blackish dark blue-green growth, 2504, February 26, 1950 (PUH, PNH); blackish dark blue-green growth, 2506, February 26, 1950 (PUH, PNH); blackish growth, 2507, February 26, 1950 (PUH, PNH, FC); blackish dark blue-green growth, 2511, February 26, 1950 (PUH, PNH, FC); dark blue-green growth, 2485, March 24, 1949 (PUH, PNH, FC); blackish growth on UP campus, 2502, February 12, 1950 (PUH, PNH).

PHORMIDIUM SUBFUSCUM Kutzing. Plate 3, fig. 54.

P. subfuscum KÜTZING, Phycolog. Gener. (1843) 195, fig. 54.

Plant mass blackish to dark blue-green; trichomes 5.5 to 11 μ wide, variously flexuous, erect, fragile, blue-green to pale rose in some specimens, sometimes slightly constricted at joints, somewhat tapering; cells distinct, protoplasm coarsely granular; end cell conical-rotund, conspicuously thickened.

Specimens examined.—PANAY: Iloilo: blackish blue-green growth on concrete base in Passi Elementary School, Passi, *JDS 1075*, July 20, 1952 (PUH, PNH, FC). LUZON: Mountain Province: dark blue-green growth along the side of Packard St., Baguio, 207, December 28, 1939 (PUH, FC); Pampanga: blackish growth on very moist flat along the highway to the Nursery, Arayat, 119, November 19, 1939 (PUH, PNH, FC; Rizal: in Mandaluyong: blackish deep blue-green growth floating on stagnant water, 173, December 10, 1939 (PUH, PNH, FC); blackish mass growing abundantly on moist sides of canal, 507, May 12, 1940 (PUH, FC); Manila: very deep blue-green growth floating on stagnant polluted water along Pennsylvania street, 103, November 18, 1939 (PUH, PNH, FC); blackish growth on walls of street canal at Pandacan, 564, August 10, 1940 (PUH, PNH, FC).

PHORMIDIUM RETZII Gomont. Plate 3, fig. 55.

P. Retzii GOMONT in Morot, Jour. Bot. 4 (1890) 355.

Plant mass thick, forming tufts, bright to pale blue-green; trichomes 4.5 to 12 μ wide, generally bright blue-green, variously flexuous, slightly constricted at joints; cells distinct, with coarsely granular protoplasm; apical cell truncate, somewhat thickened.

Specimens examined.—LUZON: Bataan: blackish growth in Lamao River, *W. R. Shaw 706*, October 10, 1907 (PUH, FC); red felt on a boulder in a brook near Third Station, Lamao Forest Reserve, *W. R. Shaw 492*, April 28, 1907 (PUH, FC). PANAY: Iloilo: dark blue-green growth on moist dam of Aganan Irrigation Project, San Miguel, JDS, June 29, 1952 (PUH, PNH, FC, NY); Laguna: blackish deep blue-green growth in Los Baños, 2468, August 14, 1948 (PUH, PNH, FC). MINDORO: Oriental Mindoro: dark blue-green growth on wet part of path at Small Tabinay, 929, April 7, 1941 (PUH, PNH, FC). LUZON: Rizal: deep blue-green growth floating as thick mats on a polluted pond in Mandaluyong, 170, December 10, 1939 (PUH, PNH, FC); Manila: dull blue-green growth on muddy surface near estero in Oregon street, 140, November 22, 1939 (PUH, FC); Quezon City: blackish deep blue-green growth in Kamuning, 2545, August 19, 1950 (PUH, PNH, FC).

PHORMIDIUM INUNDATUM Kutzing. Plate 3, fig. 56.

P. inundatum KÜTZING, Sp. Alg. (1849) 251.

Plant mass usually very dark blue-green, forming, a papery membranaceous surface; trichomes within thin, agglutinated sheaths, 3 to 5 μ wide, blue-green fragile, almost erect, straight, not constricted at cell joints; cells quadrate, lined or obscured with protoplasmic granules.

Single specimen examined.—MINDORO: Oriental Mindoro: light to dark olive-green to almost black growth in 45° to 60°C hot spring in Mainit River, Bisayaan, Puerto Galera, 1953, May 25, 1949 (PUH, PNH, FC, NY, UC).

PHORMIDIUM PAPYRACEUM Gomont. Plate 3, fig. 57.

P. papyraceum GOMONT in Morot, Jour. Bot. 4 (1890) 355.

Plant mass much expanded, very dark blue-green; trichomes blue-green, 3 to 5 μ wide within very prominent sheaths, variously interwoven, papery and fragile when dry, not constricted at cell joints, slightly tapering towards the apices; cells square to distinctly rectangular, with granular contents and conspicuous walls; apical cell usually conical, not capitate.

Specimens examined.—LUZON: Pampanga: all in Nursery, Arayat: olive-green plant mass growing abundantly under running water from a pipe, 524, May 22, 1940 (PUH, PNH, FC); deep blue-green growth submerged in clear running water near a water pipe, 132, November 19, 1939 (PUH, PNH, FC); dark blue-green growth with *P. subfuscum* in a slow running water from an artesian well, 115, November 19, 1939 (PUH, FC); very deep blue-green to black papery growth peeling off from rocks, 525, May 22, 1940 (PUH, PNH, FC); Rizal: very deep blue-green growth in Hinulugan Taktak near Antipolo, *H. H. Bartlett 15230*, April 18, 1935 (PUH, PNH);

blackish deep blue-green growth with *P. calidum* abundant on walls of a big tank at Dagat-dagatan, Navotas, 623, January 19, 1941 (PUH, PNH, FC); dark blue-green growths floating as thick mats on a polluted pond in Mandaluyong, 170, December 10, 1939 (PUH, PNH, FC, NY); Manila: very dull blue-green growth on a drained shallow canal near Normal Hall frequently wet with running water, 149, November 29, 1939 (PUH, PNH, FC).

Genus SYMPLOCA Kutzing, 1843

Filaments usually erect, coalesced or anastomosing fascicles arising from prostrate bases; trichomes generally solitary, enclosed in very thin usually firm sheaths, straight towards the apices, sometimes very slightly tapering, outer walls of apical cells somewhat thickened.

Key to the species of Symploca

1. Plants salt water	2
1. Plants fresh water	4
2. Fascicles erect. Trichomes 4 μ or more wide	3
2. Fascicles adpressed. Trichomes less than 4 μ wide.	*S. læte-viridis*
3. Trichomes 6 to 14 μ wide	*S. hydnoides*
3. Trichomes 4 to 6 μ wide	*S. atlantica*
4. Trichomes 3 μ or more wide	5
4. Trichomes 1 to 3 μ wide	6
5. Fascicles long. Trichomes 5 to 8 μ wide	*S. Muscorum*
5. Fascicles short. Trichomes 3.4 to 5 μ wide	*S. muralis*
6. Fascicles not anastomosing. Trichomes generally coarser; sheaths blue in chlorzinc iodine	*S. cartilaginea*
6. Fascicles anastomosing. Trichomes generally finer; sheaths not blue in chlorzinc iodine	7
7. Trichomes 1.3 to 2 μ wide	*S. elegans*
7. Trichomes 1.8 to 3 μ wide	*S. parietina*

SYMPLOCA LAETE-VIRIDIS Gomont. Plate 3, fig. 58.

S. læte-viridis GOMONT, Monogr. Oscill. (1893) 109, pl. 2, figs. 6–8.

Plant mass thin, agglutinated into a papery layer or in much reduced tufts, deep blue-green, cæspitose, fascicled; trichomes blue-green, closely interwoven, 1.5 to 3.5 μ wide, subparallel and flexuous, deeply constricted at cell joints, ending into a conical, unthickened apical cell; protoplasm finely granular.

Specimens examined.—LUZON: Albay: pale yellowish-green growth in Calolbon, Catanduanes, *M. Ramos* and *G. Edaño* *77257*, July to September, 1928 (PUH, PNH, FC). MINDORO:

Oriental Mindoro: in Puerto Galera: yellowish blue-green growth usually at the basal portion of *Vallisneria* plants along the shore of Small Balatero, 873, April 13, 1941 (PUH, PNH, FC).

SYMPLOCA HYDNOIDES Gomont. Plate 3, fig. 59.

S. hydnoides GOMONT in Kützing, Sp. Alg. (1849) 272.

Plant mass dark blue-green, cæspitose, fasciculate, up to 1.5 to 3 cm high; trichomes blue-green, densely interwoven and wide especially towards the base, 6 to 14 μ wide, flexible, somewhat decolorizing at the base, not constricted at cell joints, ending into a somewhat thickened apical cell; protoplasm slightly granular.

Specimens examined.—BABUYAN ISLANDS: yellowish-green growth in Calayan Islands, *R. C. McGregor 121*, November, 1903 (PUH, PNH). MINDORO: Oriental Mindoro: in Puerto Galera: light yellowish blue-green growth along the shore growing with *Vallisneria* at Small Balatero, *A. T. Feliciano* and *G. T. Velasquez 870*, April 12, 1941 (PUH, PNH, FC); light yellowish blue-green growth among *Vallisneria* grasses at Small Balatero, 870a, April 9, 1941 (PUH, PNH, FC).

SYMPLOCA ATLANTICA Gomont.

S. atlantica GOMONT, Monogr. Oscill. (1893) 109, pl. 2, fig. 5.

Filaments in tight or loose clubs; trichomes 4 to 6 μ wide, blue-green to grass-green within fairly thickened firm sheaths, constricted at cell joints, ending into a depressed-conical, slightly thickened apical cell; protoplasm somewhat granular.

SYMPLOCA MUSCORUM Gomont. Plate 3, fig. 60.

S. Muscorum GOMONT in Morot, Jour. Bot. 4 (1890) 354.

Filaments bright blue-green bundled in fascicles with thin prostrate base and free top; trichomes enclosed in tough distinct sheaths, pale to bright blue-green, 5 to 8 μ wide, loosely or tightly intertwined, not constricted at cell joints, flexuous and ending into a conical, slightly thickened apical cell; cell contents finely granulated.

Specimens examined. — MINDANAO: Agusan: bright blue-green growth with other coccoid blue-greens in Mt. Hilong-Hilong, Butuan Subprovince, 198 m on damp rock, *C. M. Weber 1334*, March to July, 1941 (PUH, PNH, NY). PANAY: Capiz: on moist soil behind the first store at the switch crossing in Tapaz, *JDS 1126*, November 27, 1952 (PUH, PNH, FC). Cebu: blue-green growth in Bantayan Island, *R. C. McGregor 112,* August 1906 (PUH). Luzon: Laguna: dark blue-green growth on irrigation ditches at Los Baños, *E. Quisumbing 77319,* October 13, 1929 (PUH); Mountain Province: in Baguio: dark blue-green tufty growths on very moist canal along Kisad Road, 196, December 27, 1939 (PUH, PNH, FC); dark blue-green growth on dry bottom of a shallow canal along Packard Road, 200, December 27, 1939 (PUH, PNH, FC); deep blue-green growth with *S. guyanense* along the side of dry canal at Packard Road, 206, December 27, 1939 (PUH, PNH, FC, UC); Pangasinan: dark blue-green growth in water-lily pond, Dagupan, 228, December 30, 1939 (PUH, FC); Rizal: in Mandaluyong: deep blue-green fascicled growth on muddy flat near pond, 168, December 10, 1939 (PUH, PNH, FC); bright blue-green growth with *P. Notarisii* and *L. lutea* on moist soil near a canal, 171, December 10, 1939 (PUH, FC); bright blue-green growth with *P. ambiguum* on dry pond, 512, May 12, 1940 (PUH, FC); bright blue-green growth on street canal at Bo. Santolan, Marikina, JDS, 907, May 12, 1952 (PUH, PNH, FC); thin, woolly olivaceous-green growth along a narrow path in a rice field at Tanay, 433, February 9, 1940 (PUH, PNH, FC); Manila: all in UP Botanical Garden: bluish-green growth with *M. vaginatus* on soil of pots, 486, April 18, 1940 (PUH, PNH, FC); purple-black growth on moist soil among grasses, 573, December 5, 1940 (PUH, PNH, FC); ash-grayish blue-green growth on moist soil near pool, 578, December 12, 1940 (PUH, PNH, FC); ash-gray blue-green growth on pots, 590, January 11, 1941 (PUH, FC); all at UP Palma Hall: deep blue-green growth with *L. Lutea* and *L. major* on plant pot at east stair, 266, January 14, 1940 (PUH, PNH, FC); bluish-green or reddish growth with *H. byssoidea* and *S. javanicum* on soil of plant pots at east entrance, 267, January 14, 1940 (PUH, PNH, FC); on UP campus: extensive blue-green growth on lawn in front of Chemistry building, 579, December 17, 1940 (PUH, FC); ash blue-green to almost lead-colored growth on flower pot near Department of Botany, 93, November 13, 1939 (PUH, PNH); deep blue-green growth, 706, March 22, 1941 (PUH, PNH, FC); blue-green growth with *P. calidum* on rotting wood along Oregon street, 147, November 22, 1939 (PUH, PNH, FC); in Paco, deep blue-green growth abundant on stonewall of estero, 138, November 22, 1939 (PUH, PNH, FC); blue-green growth abundant on side wall of old boat at estero, 139, November 22, 1939 (PUH, PNH, FC); dark blue-green growth abundant along sidewalk at San Marcelino street, 141, November 22, 1939 (PUH, PNH, FC); Quezon City: all in UP campus: blackish dark blue-green growth, 2519, February 28, 1950 (PUH, PNH, FC); deep blue-green growth, 2522 February 28, 1950 (PUH, PNH, FC); deep blue-green growth, 2430, July 22, 1950 (PUH, PNH, FC); dark blue-green growth, 2430, July 22, 1950 (PUH, PNH, FC); dark blue-green growth, 2447, July 27, 1950 (PUH, PNH, FC); dark blue-green growth, 2448, July 27, 1950 (PUH, PNH, FC); blue-green growth, 2450, July 28, 1950 (PUH, PNH, FC); blackish dark blue-green growth, 2455, July 29, 1950 (PUH, PNH, FC).

SYMPLOCA MURALIS Kutzing. Plate 3, fig. 61.

S. muralis KÜTZING, Phycolog. Gener. (1843) 201.

Filaments fasciculate or bundled, much elongated and flexuous, conspicuously blue-green; trichomes pale blue-green, 3.4 to 4 μ (–5μ) wide, within thin firm sheaths, irregularly interwoven, not constricted at joints, tapering and ending into an obtuse-conical end cell without calyptra.

Specimens examined.—LUZON: Mountain Province: in Baguio: olivaceous blue-green growth in front of Catholic Press in vicinity of Packard Road, 204, December 27, 1939 (PUH, PNH, FC); dark blue-green abundant growth with *S. Muscorum* on barks of conifers at Leonard Road, 215, December 27, 1939 (PUH, PNH, FC). MINDORO: Oriental Mindoro: very dull blue-green growth on a dry shaded pond at Hondura Hill, 1081, May 3, 1941 (PUH, PNH). PALAWAN: blue-green growth in Araceli, 2925, June 15, 1951 (PUH, PNH, FC); dark blue-green growth in Iwahig Penal Colony, 2879, June 18, 1951 (PUH, PNH, FC); blackish deep blue-green growth in Puerto Princesa, 2911b, June 20, 1951 (PUH, PNH, FC, NY); dark blue-green growth in Tapun, 2895a, June 20, 1951 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth on moist soil in front of No. 396 Tuazon street, Marikina, JDS, 998, June 3, 1952 (PUH, PNH, FC).

SYMPLOCA CARTILAGINEA Gomont.

S. cartilaginea GOMONT, Mongor. Oscill. (1893) 113, pl. 21, figs. 13, 14.

Filaments blue-green, solitary or in clumps, trichomes pale blue-green straight or subparallel, 2 to 3 μ wide, not constricted at cross-walls, within firm sheaths, ending in an apical cell with slightly thickened membrane; cell contents not granular.

Single specimen examined.—SULU: Sulu Province: blue-green growth near a well where people take a bath at Sanga-Sanga, Tawi-Tawi, 3227, May 12, 1952 (PUH, PNH).

SYMPLOCA ELEGANS Kutzing). Plate 3, fig. 62.

S. elegans KÜTZING, Phycolog. Gener. (1843) 201.

Plant mass dark blue-green, in short fascicles; trichomes tightly congested, moderately flexuous, narrow, parallel in most specimens, 1.3 to 2 μ wide, rich blue-green, lightly to strongly constricted; protoplasm not granular; apical cell subconical, without calyptra.

Specimens examined.—LUZON: Laguna: blackish growth along path to Students' Mess Hall, Forestry Camp, Los Baños, 291, January 28, 1940 (PUH, PNH, FC); Pampanga: bluish-green growth with *S. ocellatum* on rocky walls of canal at Nursery, Arayat, 521, May 22, 1940 (PUH, PNH, FC); Manila: blue-green growth on wet soil along the sidewalk at Pennsylvania street, 99, November 18, 1939 (PUH, PNH, FC); blue-green growth with *Phormidium* sp. and *P. fragile* under continuously dripping water in a boys' dormitory, 176, December 10, 1939 (PUH, PNH, FC); dark blue-green growth with *Phormidium* sp. and *P. fragile* on a street canal, Vito Cruz Subdivision, *F. Salas* and *G. T. Velasquez 422*, February 4, 1940 (PUH, PNH, FC); deep blue-green growth with *P. tenue* along Padre Faura street, 658, December 21, 1940 (PUH, PNH, FC); bluish-green growth on damp shaded soil at premises of Philippine Long Distance Telephone Company, Marques de Comillas, 586, January 8, 1941 (PUH, PNH, FC).

SYMPLOCA PARIETINA Gomont. Plate 3, fig. 63.

S. parietina GOMONT, Monogr. Oscill. (1893) 116.

Plant mass dark blue-green, sometimes light yellow trichomes irregularly intertwined, narrow 1.8 to 3 μ wide, not constricted at cell joints; protoplasm not granulated, but at times with conspicuous pair of granules in each cell; apical cell rotund, without calyptra.

Single specimen examined.—PALAWAN: dark blue-green growth in Iwahig Penal Colony, 2871, June 18, 1951 (PUH, PNH, FC).

Genus LYNGBYA C. Agardh, 1824

Filaments usually collected in floccose expanded masses floating on water; solitary specimens grow intermingled with other algæ; unbranched filaments enclosed in very firm sheaths of variable thickness which are lamellose in some species; some trichomes constricted at cell joints, very slightly tapering towards their apices with apical cell usually not capitate.

Key to the species of Lyngbya

1. Plants marine or brackish water 2
1. Plants fresh water 6
    2. Sheaths variously colored 3
    2. Sheaths always hyaline 4
3. Filaments usually bundled, sheaths smooth, more or less straight and rigid. Apices of trichomes not tapering nor capitate, 14 to 31 μ wide .... *L. sordida*
3. Filaments variously entangled, sheaths ragged, generally flexuous. Apices of trichomes slightly tapering and capitate, 8 to 24 μ wide. *L. æstuarii*
    4. Trichomes generally wider, not tapering nor capitate 5
    4. Trichomes generally narrower, 5 to 12 μ wide, tapering and capitate .... *L. semi-plena*
5. Trichomes 16 to 60 μ, generally 20 to 40 μ wide .... *L. majuscula*
5. Trichomes 9 to 12 μ wide .... *L. confervoides*
    6. Filaments elongate, loosely flexuous. Trichomes constricted cells quadrate .... *L. putealis*
    6. Filaments elongate, closely entangled. Trichomes not constricted, cells subquadrate .... *versicolor*

LYNBYA SORDIDA Gomont. **Plate 3, fig. 64.**

L. sordida GOMONT, Monogr. Oscill. (1893) 126, pl. 2, fig. 21.

Plant mass forming fascicles, bright blue-green, sometimes purplish-violet to dull-green; filaments soft woolly and easily disentangled; trichomes loosely intertwined, 14 to 31 μ wide, somewhat straight, purple-violet, apparently constricted at joints, enclosed in thin, or sometimes thick and smooth sheaths which are transparent in many specimens, not tapering toward the apices; protoplasm thick and oftentimes conspicuously granular, transverse walls at times not conspicuous, apical cell rotund, not capitate.

Specimens examined. — BABUYAN ISLANDS: yellowish blue-green growth on coral limestone near the shore of Calayan Islands, *R. C. McGregor 22*, September 30, 1903 (PUH); deep blue-green growth in Calayan Islands, *R. C. McGregor 19a*, November 1903 (PUH); yellowish blue-green growth with *Hydrocoleum cantharidosmum* in Dalupiri Island, *H. H. Bart-*

lett 14998, October 31, 1935 (PUH, PNH). CEBU: olive-green to purple growth in Liloan Beach, east coast of Cebu Island, 18 km northeast of Cebu, *H. H. Bartlett 16205,* September 20, 1935 (PUH, PNH). MINDORO: Oriental Mindoro: all in Puerto Galera: greenish-purple growth used by a crustacean, *Alpheus pachychirus,* in making a tube, R. P. Cowles, May 1912 (PUH); greenish-purple growth in salt water, R. P. Cowles, no number, May, 1912 (PUH, PNH, NY); yellowish blue-green growth in Boquete, *H. H. Bartlett 14031,* 1935 (PUH, PNH); dull yellowish blue-green growth on *Thalassia* leaves along the shore at Paniquian Island, 845, April 8, 1941 (PUH, PNH, FC); yellowish-green growth drifted at Paniquian Island, 971, April 16, 1941 (PUH, PNH, FC); yellowish blue-green growth in Northwest Channel at Paniquian Island, 988, April 24, 1941 (PUH, PNH, FC).

LYNBYA AESTUARII Liebman. Plate 3, fig. 65.

L. æstuarii LIEBMAN in Kroyer's Nat. Tids. (1838) 492.

Plant mass widely expanded, floating compact woolly layer up to 1 mm in thickness, blue-green to very dark blue-green; trichomes of various hues, 8 to 24 μ wide, moderately flexuous and variously entangled, not constricted at cell joints, slightly tapering towards the apices; sheaths thin when young, thickening and becoming lamellose on maturity; cells very narrow and with finely granulated protoplasm; end cell truncate, slightly thickened, others slightly capitate.

Growing abundantly in brackish-water fishponds.

Specimens examined. — BABUYAN ISLANDS: in Calayan Island: yellowish-green growth on coral limestone near shore, *R. C. McGregor 29a,* September 30, 1903 (PUH); dark yellowish-green growth, *R. C. McGregor 29,* November, 1903 (PUH); yellowish-brown growth in Camiguin Island, *R. C. McGregor 124,* July, 1907 (PUH, PNH). LUZON: Bataan: blackish dark blue-green growth in Panilao, Pilar, 2417, July 13, 1950 (PUH, PNH, FC); dark blue-green growth in Tuyo, Balanga, 2420, July 14, 1950 (PUH, PNH); Bulacan: in Hagonoy: brownish olivegreen growth, 27, October 28, 1935 (PUH, PNH); yellowish-green floating mass on very shallow beds of fishponds, *G. T. Velasquez* and *J. V. Santos,* no number, April 28, 1936 (PUH). PANAY: Iloilo: bright blue-green growth floating extensively on fishponds along General Luna street, Iloilo City, *JDS 1003,* June 20, 1952 (PUH, PNH, FC, NY). LU-

ZON: Laguna: in Los Baños: blackish growth, 2461, August 8, 1948 (PUH, PNH, FC); dark blue-green growth, 2472, August 14, 1948 (PUH, PNH, FC). LUZON: Leyte: blue-green growth on soil in shallow, almost dry pond one mile west of Palo, *M. E. Britton 168,* November 26, 1945 (PUH, PNH); floating in shallow pool two miles south of Palo, *M. E. Britton 149,* October 10, 1945 (PUH, FC); grass-green to olive-green material partly on mud and partly floating on surface of shallow pond one mile west of Palo, *M. E. Britton 170,* November 26, 1945 (PUH, PNH, FC); bright blue-green to olive-greenish growth floating on surface but partially resting on mud in shallow water one mile west of Palo, *M. E. Britton 171,* November 26, 1945 (PUH). MINDORO: Oriental Mindoro: in Puerto Galera: light bluish-green growth submerged in shallow brackish water stream at Big Balatero, 941, April 22, 1941 (PUH); bright blue-green growth floating on brackish water at Big Balatero, 942, April 22, 1941 (PUH, PNH, FC). PALAWAN: blackish dark blue-green growth in Araceli, 2921, June 15, 1951 (PUH, PNH, FC, NY); in Cuyo, grass-green to dark blue-green felty growth, 2814, June 11, 1951 (PUH, PNH, FC, NY); bright and dark green to blackish felty growth, 2816, June 11, 1951 (PUH, PNH, FC, NY); bright to dark blue-green growth in Iwahig Penal Colony, 2876, June 18, 1951 (PUH, PNH, FC, NY); dull dark blue-green growth in Puerto Princesa, 2916, June 21, 1951 (PUH, PNH, FC). LUZON: Pangasinan: in Dagupan: blackish deep blue-green growth floating with *M. chthonoplastes* as very thick mat on brackish water of fishpond, 229, December 30, 1939 (PUH, PNH, FC); blackish dark blue-green growth floating with *L. majuscula* and *M. lacustris* as very thick mat on brackish water of fishpond, 231, December 30, 1939 (PUH, PNH, FC); very dull blue-green growth with *O. sancta* and *M. chthonoplastes* on moist soil near canal along the highway, 234, December 30, 1939 (PUH, PNH, FC); Rizal: in Las Piñas: dark blue-green growth in brackish water pool, *E. Quisumbing 249a,* July 27, 1931 (PUH); grass-green growth in fishpond, *E. Quisumbing 249b,* July 27, 1931 (PUH); dark-green growth in salt-water pond, *E. Quisumbing 249c,* July, 1931 (PUH); blue-green growth on brackish-water fishpond, *F. del Rosario 318a-2,* March 4, 1932 (PUH); blackish blue-green growth, 2532, March 13, 1950 (PUH, PNH, FC, NY); in Dagat-dagatan, Navotas: olive-green to blackish dark blue-green abundant growth on *Chætomorpha* in brackish-water fishpond, 186, December 13, 1939 (PUH, PNH); dark blue-green growth floating on fishponds, 629, January 19, 1941 (PUH, PNH, FC); dark blue-green growth floating on fishponds, 630, January 19, 1941 (PUH, PNH); dark blue-green growth on moist banks of Marikina River at Bo. Calumpang, Marikina, JDS, 894, April 20, 1952 (PUH, PNH, FC); olive-green growth with *Entophysalis conferta* in Parañaque, *M. T. Cruz 19555*, August, 1933 (PUH); Manila: olive-green growth with *E. conferta* on brackish water in fishponds in Manila and vicinity, *E. D. Merrill 7458*, January, 1911 (PUH); growing wtih *M. chthonoplastes, L. major* and *M. lacustris* forming blackish, leathery mass on walls of street canal at Vito Cruz Subdivision, 421, February 4, 1940 (PUH); dark blue-green to greenish growth floating on street canal along San Nicolas street, JDS, 436, October 21, 1949 (PUH, PNH, FC); Quezon City: dark blue-green growth on UP campus, 2457, July 29, 1950 (PUH, PNH, FC).

LYNBYA SEMI-PLENA J. Agardh. Plate 3, fig. 66.

L. semi-plena J. AGARDH, Algæ maris Mediterranei et Adriatici (1842) 11.

Plant mass extensive, growing up to 3 cm in height, dark to yellow blue-green, yellow-green in some specimens; trichomes blue-green, 5 to 12 μ wide, very loosely flexuous, not constricted at joints, with finely granular contents, somewhat tapering towards the apices; end cell capitate, depressed-conical.

Specimens examined.—MINDORO: Oriental Mindoro: yellowish blue-green growth with *L. confervoides* in a tide pool from rocky cliffs at Paniquian, Puerto Galera, 843, April 8, 1941 (PUH, PNH). LUZON: Rizal: yellowish blue-green to blue-green growth in Pasay, *H. H. Bartlett 16261*, 1935 (PUH, PNH).

LYNBYA MAJUSCULA Harvey. Plate 4, fig. 68.

L. majuscula HARVEY in Hooker's Engl. Flora part 1 5 (1833) 370.

Plant mass very extensive, blue-green, grass-green, becoming yellowish-purple; trichomes coarse, 16 to 60 μ wide, enclosed in usually thick, roughened and rugged sheaths up to 11 μ wide; cells narrow, not attenuate, blue-green, not constricted at joints, very finely granulated, usually almost homogeneous; end cell rotund, without calyptra.

Deformed trichomes are usually separated from rugged sheaths owing probably to age.

Specimens examined.—BABUYAN ISLANDS: in Calayan Island: yellowish blue-green growth; *R. C. McGregor 19,* November, 1903 (PUH); yellowish blue-green growth, *R. C. McGregor 42,* 1903 (PUH, PNH); grass-green growth, *R. C. McGregor 44,* 1903 (PUH); yellowish-brown growth in Camiguin Island, *R. C. McGregor,* July, 1907 (PUH). LUZON: Bataan: in Cabcaban: purplish blue-green growths on rocks about 1 m below sea in Lamao, *W. R. Shaw 1127,* May 9, 1911 (PUH); purplish blue-green growth on rocks about 1 m below sea, *W. R. Shaw 1134,* May 9, 1911 (PUH, PNH, UC). PANAY: Cebu: yellowish blue-green growth, *R. C. McGregor 90,* no year, (PUH). LUZON: Laguna: blue-green growth in fishpond in Los Baños, *E. Quisumbing 262-a-2,* October 16, 1931 (PUH, UC). MINDORO: Oriental Mindoro: in Puerto Galera: yellowish dark blue-green growth with *H. cantharidosmum* on little Balatero side of Boquete, *H. H. Bartlett 14033,* April, 1935 (PUH, PNH); dark blue-green growth, *H. H. Bartlett 13956,* May 12 to 17, 1935 (PUH); bright blue-green growth in Lubang, *Herculana S. Villaflores 32,* September 11 to 17, 1935 (PUH, PNH); yellow-green to purplish blue-green algæ attached to sand usually exposed during the low tide at Paniquian Island, 834, April 8, 1941 (PUH, PNH); purplish dark blue-green growth submerged during high tide at Paniquian Island, 914, April 10, 1941 (PUH, PNH); yellowish blue-green growth along the shore of Paniquian Island, 914a, April 10, 1941 (PUH, PNH); dark blue-green growth drifting along the shore at Northwest Channel, Paniquian Island, 833, April 16, 1941 (PUH, PNH); yellowish blue-green growth on shore exposed to strong waves at Paniquian Island, 846, April 16, 1941 (PUH, FC); dark purple-blue-green growth with *H. comoides* drifted by waves at Hondura, Varadero Bay, 922, April 12, 1941 (PUH, PNH); yellowish greenish-purple growth with *L. sordida* floating or drifted along the shore of Big Balatero, 871, April 12, 1941 (PUH, PNH, FC); dark purplish blue-green growth on sand along the shore exposed to waves at Medio Island, 915, April 17, 1941 (PUH, PNH, FC); olive-green to brownish blue-green growth in Northwest Muelle, 1171, April 20, 1948 (PUH, PNH, FC); yellowish blue-green growth in first plateau, 1717, April 23, 1948 (PUH, PNH, FC). PALAWAN: olive dark blue-green growth in Araceli, 2941, June

15, 1951 (PUH, PNH, FC, NY); in Cuyo; dark blue-green growth in Catadman Sound, 3023, June 6, 1951 (PUH, PNH, FC); purple-brown to olive-green growth in Catadman Sound, 3025, June 6, 1951 (PUH, PNH, FC); bright blue-green growth in Putik Sound, 3029, June 7, 1951 (PUH, PNH, FC, NY); brownish-greenish growth with *L. æstuarii* at Malampaya Sound, *G. T. Velasquez* and *H. A. Roxas 613,* May 25, 1940 (PUH, PNH, FC). LUZON: Rizal: light blue-green growth in fishpond at Las Piñas, *E. Quisumbing 262-c-4,* October 16, 1931 (PUH, PNH); light grayish blue-green growth with *L. majuscula* in Dagat-dagatan, Malabon, *E. Quisumbing 8,* October 9, 1937 (PUH, PNH). SULU: dark blue-green growth south of Siasi Island channel lined on both sides with mangrove, between Lapak and Tagtagan islands, *H. H. Bartlett 16209,* September 15, 1935 (PUH).

LYNBYA CONFERVOIDES A. Agardh. Plate 3, fig. 67.

L. confervoides A. AGARDH, Syst. Alg. (1824) 73.

Plant mass forming fascicles up to 2 to 3 cm in height, violet to yellowish blue-green, clumped tightly when dried; trichomes blue-green, 9 to 25 μ wide, loosely flexuous, not constricted at joints, easily detached from very hyaline lamellose sheaths as thick as 5 μ, granulated, not tapering towards the apices; apical cell rotund, not capitate.

Specimens examined.—PANAY: Cebu: yellowish-green growth in Liloan Beach east coast of Cebu Island and 18 km northeast of Cebu, *H. H. Bartlett 16209a,* September 20, 1935 (PUH). MINDORO: Oriental Mindoro: in Puerto Galera: very light yellowish-green growth along the shore submerged at high tide, Paniquian Island, 844; April 8, 1941 (PUH, FC); light yellowish blue-green growth on submerged sandy shore where *Thallasia* beds are found at Paniquian, 844a, April 8, 1941 (PUH, FC); very dark blue-green growth in Mahabang Parang, 1741, May 5, 1948 (PUH, PNH, FC). PALAWAN: yellowish blue-green growth at Araceli 2936, June 15, 1951 (PUH, PNH, FC, NY); yellowish blue-green growth at Catadman Sound, Cuyo, 3027, June 6, 1951 (PUH, PNH, FC, NY).

LYNBYA PUTEALIS Montagne. Plate 4, fig. 69.

L. putealis MONTAGNE, Ann. Sci. Nat. Bot. series 2e 13 (1840) 200.

Plant mass expanded forming penicillate growth, dark blue-green, light violet and fragile in many dried specimens; trichomes extensive, 7.5 to 13.0 μ wide, very long, at times loosely bundled, with very thin colorless sheaths, constricted at joints, not attenuated towards the apex; cells quadrate, with distinct transverse walls and granular protoplasm, end cell rotund, not capitate.

Specimens examined.—LUZON: Laguna: dark blue-green growth on moist soil in Los Baños, *E. Quisumbing 77315*, October 13, 1929 (PUH). MINDANAO: Lanao: yellowish blue-green growth in Cristina Falls, *Liborio Ela Ebalo 1203*, February 26 to March 30, 1941 (PUH). LEYTE: blue-green stratum on floating roots of water hyacinth in lagoon at estuary of Linbuyan River near Tanean, *M. E. Britton 110*, August 1, 1945 (PUH, PNH). MINDORO: Oriental Mindoro: in Puerto Galera: violet blue-green growth attached to rocks of a fast-running stream at Small Tabinay, 927, April 7, 1941 (PUH, PNH, FC); dark blue-green growth along one side of stream at San Isidro, 960, April 23, 1941 (PUH, PNH, FC); dark blue-green growth floating in stream at San Isidro, 961, April 23, 1941 (PUH, PNH, FC); dark blue-green growth floating as mats on still water near waterfalls at Bisayaan, 1091, May 5, 1941 (PUH, PNH); light purplish-green to dark blue-green growth in lukewarm water at Tabinay, 1624, April 28, 1948 (PUH, PNH, FC); purplish blue-green growth in warm spring (33° to 34°C) in Small Tabinay, 1874, May 4, 1949 (PUH, PNH, FC, NY); dark blue-green growth with *O. tenuis* in fresh water in Bulacao, *C. B. Robinson 6704*, March 17, 1909 (PUH).

LYNBYA VERSICOLOR Gomont. **Plate 4, fig. 70.**

L. versicolor GOMONT, Monogr. Oscill. (1893) 147, pl. 4, figs. 4, 5.

Plant mass forming thin, dark to bright blue-green, sometimes purplish growth; trichomes long and very slender, evidently flexuous, 2.8 to 3.2 μ wide, within thin colorless sheaths, blue-green, not constricted at joints; cells quadrate, pellucid at joints, contents not granulated; apical cell rotund.

Specimens examined.—MINDORO: Oriental Mindoro: bright blue-green growth in laboratory bottle in Department of Zoology at the Marine Biological Station, *G. T. Velasquez* and *A. T. Feliciano 935*, April 19, 1941 (PUH, FC). LUZON: Manila: light greenish-blue growth with *Symploca muralis* on walls of cemented tank at Botanical Garden, 593, January, 1941 (PUH, FC).

Genus PORPHYROSIPHON Kutzing, 1849

Filaments growing as abundant feltlike expansions on moist soil or on embankments with moderate supply of moisture; sheaths firm, usually solid and lamellose, reddish colored; trichomes usually flexuous or slightly tapering towards the apices; cells are generally quadrate, apical cells not capitate.

Key to the species of Porphyrosiphon

1. Filaments purplish-red, trichomes 8 to 19 μ wide, transverse wall evidently constricted. .... *P. Notarisii*
1. Filaments greenish-brown, trichomes much narrower, transverse wall very lightly or not at all constricted 2
    2. Trichomes 4 to 6.6 μ wide .... *P. fuscus*
    2. Trichomes generally narrower, 3 to 5 μ wide .... *P. Velasquezii*

PORPHYROSIPHON NOTARISII Kutzing. Plate 4, fig. 71.

P. Notarisii KÜTZING, Tab. Phycolog. 2 (1850–1852) 7, pl. 27, fig. 1.

Plant mass generally feltlike with extended indefinite growth, blue-green when young, becoming reddish-purplish in maturity; trichomes 8 to 19 μ wide, loosely flexuous and entangled; sheaths striated, becoming fribillose when empty; trichomes blue-green, becoming reddish, deeply constricted at cell joints, granulated, attenuate and ending in a rotund apical cell.

Specimens examined. — PANAY: Antique: greenish-blue growth on bark of mango tree in Central School grounds, San Jose, *JDS 1526*, December 11, 1952 (PUH, PNH, FC). LUZON: Bataan: dark blue-green growth in Tuyo, Balanga, 2424, July 14, 1950 (PUH, PNH, FC); purplish blue-green growth in Panilao, Pilar, 2414, July 13, 1950 (PUH, PNH, FC); Laguna: all in Los Baños: dark blue-green growth on coconut trunk, *E. Quisumbing 77302*, October 13, 1929 (PUH, PNH, FC); dark purple growth on embankment of roadway to creek at foot of Mt. Makiling, 381, January 28, 1940 (PUH, PNH. FC); reddish-purple dark blue-green growth, 2469, August 14, 1948 (PUH, PNH, FC); bright blue-green growth 2473, August 14, 1948 (PUH, PNH, FC); dull dark blue-green growth, 2475, August 14, 1948 (PUH, PNH, FC); dark purple growth peeling off from trunk of coconut palm along the shore of Sampaloc Lake, San Pablo City, 450, February 25, 1940 (PUH, PNH, FC). LEYTE: yellowish to olive-green layer on soil in bare shaded areas of lawn occurring as dry and rather "hairy" appearing mat that peeled easily from soil one mile west of Palo, *M. E. Britton 176*, November 1945 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: dark purple growth on very dry soil with dry grasses at Hondura Hill, 1079, May 3, 1941 (PUH, PNH); dark purple growth along very dry embankment of new highway to Dulangan, 1090, May 5, 1941 (PUH, PNH); dark purple growth along dry path at Balatero Hill, 1115, May 7, 1941 (PUH, PNH); deep purple growth peeling off from cliffs high above the tide mark at Small Tabinay, 1131, May 8, 1941 (PUH, PNH). PALAWAN: all in Cuyo: deep purple growth, 2803, June 10, 1951 (PUH, PNH, FC, NY); dark purplish blue-green growth, June 13, 1951 (PUH, PNH, FC NY); deep purple blue-green growth, 2847, June 9, 1951 (PUH, PNH, FC); deep blue-green growth in Puerto Princesa, 2902, June 19, 1951 (PUH, PNH, FC, NY); purplish blue-green growth in Araceli 2923, June 15, 1951 (PUH, PNH, FC). LUZON: Pangasinan: blackish purple or reddish somewhat woolly coating on bark of old mango tree at Bayambang, 469, March 24, 1940 (PUH, PNH, FC); Rizal: dark purplish flakelike growth peeling off from old stone wall of rice mill at Marikina, 414, February 2, 1940 (PUH, PNH, FC); blackish-purple growth on damp corner of adobe walls of house west of the public market in San Mateo, JDS, 974, May 27, 1952 (PUH, PNH, FC); thin dark purplish growth peeling on trunks of citrus, Tanay, 434, February 9, 1940 (PUH, FC); all in Mandaluyong: dark purple growth on dry grassy surface, 175, December 10, 1939 (PUH, PNH, FC); reddish growth covering the banks of small pond, 511, May 12, 1940 (PUH, PNH, FC); dark grayish growth on moist grass field, 160, December 10, 1939 (PUH, FC); Manila: both in Pandacan: blue-green growth with *S. ocellatum* on old stone wall of church, 566, August 10, 1940 (PUH, FC); blackish dark green growth on walls of church, 565, August 10, 1940 (PUH, PNH, FC); Quezon City: in Balara: purplish blue-green growth, 550, August 26, 1950 (PUH, PNH, FC, NY); dark blue-green growth, 2481, March 13, 1949 (PUH, PNH, FC); in Cubao: dark purple growth, 2488, December 28, 1949 (PUH, PNH, FC); dark purple growth, 2489, December 31, 1941 (PUH, PNH, FC); greenish dark purple to black growth in Kamuning, 2493, January 29, 1949 (PUH, PNH, FC, NY); in UP campus: dark purple growth, 2521, February 28, 1950 (PUH, PNH, FC); dark purple growth, 2517, February 28, 1950 (PUH, PNH, FC, NY).

PORHYROSIPHON FUSCUS Gomont. Plate 4, fig. 72.

P. fuscus GOMONT in Fremy, Bull. Mus. Nat. Hist. (1927) 115, fig. 1a, b.

Plant mass purplish-brown, dark to light blue-green; filaments flexuous, moderately entangled; trichomes within firm, colorless sheaths which are empty in several specimens; cell joints not constricted; protoplasm granular; end cell rotund, slightly thickened.

Specimens examined. — PANAY: Iloilo: grayish blue-green growth on moist soil beside north gate of UPIC, Iloilo City, 1045, June 24, 1952 (PUH, PNH, FC). LUZON: Mountain Province: blackish growth with *Anabæna catenula* on moist soil in front of Vallejo Hotel, Baguio, 216, December 27, 1939 (PUH, FC). PALAWAN: light blue-green growth in Puerto Princesa, 2917, June 21, 1951 (PUH, PNH, FC); dark blue-green growth on moist soil bank of Marikina River at Bo. Malanday, Marikina, 925, May 17, 1952 (PUH, PNH, FC).

PORHYROSIPHON VELASQUEZII Drouet. Plate 4, fig. 73.

P. Velasquezii DROUET, Field Mus. Nat. Hist. Bot. Ser. 20 (1942) 130, pl. 1, fig. 5.

Plant mass thin, dark to light blue-green; filaments flexuous, bright blue-green; trichomes enclosed in colorless sheaths; cells rectangular, not constricted at cell joints, granulated; end cell rotund, not thickened.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: dark blue-green growth on one side of campus usually wet with fresh water from laboratory of Biological Station, 1077, May 2, 1941 (PUH, PNH); dark blue-green growth along the path at Dulangan, 1093, May 5, 1941 (PUH, PNH); dark blue-green growth on side of a dry pond at Hondura Hill, 1082, May 3, 1941 (PUH). LUZON: Manila: dark blue-green growth with *S. guyanense* and *S. Muscorum* along sidewalk of Pennsylvania street, Ermita, 98, November 18, 1939 (PUH, FC).

Genus SCHIZOTHRIX Kutzing, 1843

Growing mostly in moist soil or in moist embankments; filaments forming erect or prostrate *Symploca*-like *fascicles;* sheaths variously colored; trichomes mostly tightly packed and twisted in usually rugged sheaths.

Key to the species of Schizothrix

1. Trichomes not constricted 2
1. Trichomes constricted 5

2. Trichomes 2.5 to 6 μ wide 3
2. Trichomes much narrower 4
3. Trichomes 4 to 6 μ wide, apical cell with thicker outer membrane. *S. Stricklandii*
3. Trichomes 2.5 to 4.5 μ wide, apical cell without thick outer membrane. *S. rubella*
4. Trichomes 1 to 1.7 μ wide, sheaths distinctly acuminate. *S. calcicola*
4. Trichomes 1.5 to 2 μ wide, sheaths not distinctly acuminate *S. lardacea*
5. Trichomes up to 4 μ wide only 6
5. Trichomes mostly always wider 9
6. Trichomes 2 to 2.5 μ wide, sheaths evidently violet .. *S. violacea*
6. Trichomes in sheaths never violet 7
7. Trichomes 1.3 to 1.6 μ wide, numerous and loosely aggregated in the sheath .... *S. lateritia*
7. Trichomes never numerous in the sheaths 8
8. Trichomes evidently constricted, 1.4 to 2.4 μ wide ... *S. tinctoria*
8. Trichomes slightly constricted, 3 to 4 μ wide .... *S. Lamyi*
9. Trichomes widely variable, 4 to 9 μ wide, apical cell rotund. *S. thelephoroides*
9. Trichomes not widely variable in width, apical cell generally acute-conical or acuminate 10
10. Trichomes 4 to 6 μ wide, apical cell long and acute-conical up to 2 to 3 cells away from the tip .... *S. acuminata*
10. Trichomes 6 μ to mostly wider, apical cell not so markedly acute-conical 11
11. Trichomes very markedly constricted, protoplasmic contents less granular .... *S. chalybea*
11. Trichomes moderately constricted, protoplasmic contents coarsely granular .... *S. purpurascens*

SCHIZOTHRIX STRICKLANDII Drouet.

Plate 4, figs. 74 and 74a.

S. Stricklandii DROUET, Amer. Midl. Nat. 29 (1943) 51.

Filaments in loose symplocoid fascicles, loosely entangled and several in a sheath, striated and generally splitting and agglutinated; trichomes deep blue-green, 6 μ or less wide on the average, not constricted at cell joints; cells rectangular, with coarsely granulated protoplasm; end cell rotund-conical somewhat thickened.

Single specimen examined.—PANAY: Capiz: dark blue-green growth on soil in front of house at km 25, Bo. Amaga, Sigma, JDS, 1517, November 30, 1952 (PUH, PNH, FC).

SCHIZOTHRIX RUBELLA Gomont.

Plate 4, figs. 75 and 75a.

S. rubella GOMONT, Monogr. Oscill. (1893) 38, pl. 6, figs. 4, 5.

Plant mass in scattered pulvini among *Microcoleus paludosus*, pale purplish to blue-green; filaments enclosed in moderately thick, slightly calcified sheaths, somewhat brittle when dried; trichomes flexuous, usually one in a striated sheath, rarely two or three, bright blue-green; cells long, not constricted at cell joints, granulated; end cell rotund, without thickening.

Single specimen examined.—PANAY: Iloilo: dark purplish blue-green growth on moist soil among grasses exposed to sun and rain inside ruins of Catholic church in Dueñas, *JDS 1081*, July 20, 1952 (PUH, PNH, FC).

SCHIZOTHRIX CALCICOLA Gomont. Plate 4, figs. 76 and 76a.

S. calcicola GOMONT, Monogr. Oscill. (1893) 45, pl. 8, figs. 1–3.

Plant mass light yellow to dark blue-green, becoming hard when dry, very lightly calcified, papery, sub-cartilaginous; filaments strongly agglutinated, usually solitary, seldom two in a firm sheath, short and very densely entangled; trichomes pale blue-green, 1 to 1.7 μ wide, not constricted at cell joints, each cell marked by two protoplasmic granules, end cell rotund.

Specimens examined.—PANAY: Iloilo: blackish dark blue-green growth floating on fountain in town plaza of Cabatuan, *JDS 1111*, November 16, 1952 (PUH, PNH, FC). PALAWAN: deep blue-green growth in Puerto Princesa, 2911a, June 20, 1951 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth submerged in concrete tanks in Camp Parang, Marikina, JDS, 919, May 16, 1952 (PUH, PNH, FC).

SCHIZOTHRIX LARDACEA Gomont. Plate 5, figs. 77 and 77a.

S. lardacea GOMONT, Monogr. Oscill. (1893) 49, pl. 8, figs. 8, 9.

Plant mass quite extensive, slightly calcified, purple to yellowish elastic and up to 1.5 cm thick when fresh; filaments variously and loosely entangled, generally solitary, elongate within firm usually acuminate sheaths; trichomes (1.5–) 1.2 to 2.3 (–2) μ wide, not constricted at cell joints; apical cell rotund; paired protoplasmic granules conspicuous in each cell.

Single specimen examined.—MINDORO: Oriental Mindoro: light orange-pink to grayish blue-green growth at Bisayaan, Puerto Galera, 1956, May 25, 1949 (PUH, PNH, FC, NY).

SCHIZOTHRIX VIOLACEA Gardner.

S. violacea GARDNER, Mem. New York Bot. Gard. 7: 52. pl. 11, fig. 99.

Plant mass light yellow to blue-green, evidently calcified, slightly mucilaginous; filaments growing with other algæ, 7 to 11 μ wide, loosely entangled, tortuous, within thick, usually irregular and ragged sheaths which are closed and acuminate, striated; trichomes (2.3–) 2 to 2.5 μ wide, bright blue-green, slightly constricted at cell joints, a pair of conspicuous protoplasmic granules present in each cell; end cell rotund.

Single specimen examined.—LUZON: Laguna: blue-green growth with *Fischerella ambigua* and *Chroothece monococca* on embankment of a pond at Los Baños, 387, January 28, 1940 (PUH, FC).

SCHIZOTHRIX LATERITIA Gomont. Plate 5, figs. 78 and 78a.

S. lateritia GOMONT, Monogr. Oscill. (1893) 46, pl. 8, figs. 4, 5.

Plant mass in indefinite cushions, light purple to dark blue-green in widely expanded diffluent sheaths: filaments very densely intertwined; trichomes blue-green, usually very numerous in the sheath, 1.3 to 1.6 μ wide, constricted at cell joints, paired protoplasmic granules conspicuously present in many specimens; end cell rotund.

Single specimen examined.—LUZON: Manila: blackish dark blue-green growth on damp, mossy adobe wall at No. 586 Int. Lardizabal street, JDS, 605, January 1, 1950 (PUH, PNH, FC, NY).

SCHIZOTHRIX TINCTORIA Gomont. Plate 5, figs. 79 and 79a.

S. tinctoria GOMONT in Morot, Jour. Bot. 4 (1890) 351.

Plant mass dark to bright blue-green; filaments very much elongate and loosely entangled within firm, closed, not lamellose and somewhat diffluent sheaths; trichomes 1.4 to 2.4 μ wide, numerous, markedly constricted at cell joints; protoplasm finely granular, a pair of coarser granules conspicuous in each cell; end cell rotund.

Single specimen examined. — MINDORO: Oriental Mindoro: dark blue-green growth on surface of water in a canal at poblacion of Puerto Galera, 716, March 30, 1941 (PUH, PNH, FC).

SCHIZOTHRIX LAMYI Gomont. Plate 5, figs. 80 and 80a.

S. Lamyi GOMONT in Bornet, Bull. Soc. Bot. France (1891) 250, pl. 38.

Filaments growing among other algæ, moderately elongate, thick, rich purple; sheaths thick, irregularly, finely lamellose; trichomes few in the sheaths, separate from each other, 3 to 4 μ thick, blue-green generally slightly constricted at cell joints; cells long, protoplasmic contents granular; end cell truncate.

Specimens examined.—LUZON: Mountain Province: dark purple leathery growth peeling off from side of embankment along

Session Road, Baguio, 190, December 28, 1939 (PUH, PNH, FC); dark purple growth with *F. ambigua* on embankments along roadside at Antipolo, 666, January 25, 1941 (PUH, PNH, FC).

SCHIZOTHRIX THELEPHOROIDES Gomont. Plate 5, figs. 81 and 81a.

S. thelephoroides GOMONT, Monogr. Oscill. (1893) 57, pl. 10, figs. 1–4.

Plant mass caespitose, usually ragged; filaments subdichotomously divided, acuminate; trichomes 4 to 9 μ wide, generally solitary or paired in ragged, highly red-colored lamellose sheaths, constricted at cell joints, somewhat tapering towards the apices, end cell generally truncate; protoplasm coarsely granular.

Specimens examined.—PANAY: Iloilo: deep reddish-purple growth on damp ground in Guimaras Island at alt. of 50 m, *C. B. Robinson 18014*, December 24, 1912 (PUH, PNH, FC). LUZON: Mountain Province: very dry, usually dark purple growth on wayside, Baguio, 211, December 28, 1939 (PUH, PNH, FC).

SYMPLOCA ACUMINATA (Gardner) Drouet. Plate 5, fig. 82.

S. acuminata (Gardner) DROUET, Field Mus. Nat. Hist. Bot. Ser. 20 (1943) 162.

Filaments several in a wide and ragged sheath; trichomes blue-green, 3 to 5.5 μ wide, constricted at cell joints; protoplasm granular; end cell acuminate and closely resembling *Microcoleus lacustris.*

Single specimen examined.—LUZON: Manila: greenish, woolly growth on Padre Faura street, side of Palma Hall, UP, 92, November 12, 1939 (PUH, NH, FC).

SYMPLOCA CHALYBEA Gomont. Plate 6, figs. 83 and 83a.

S. chalybea GOMONT, Monogr. Oscill. (1893) 57, pl. 9, figs. 3–5.

Plant mass consisting of an indefinite number of filaments in very thick sheaths as much as 12 μ wide, even wider in some specimens; finely and conspicuously lamellose, lead to light dark colored; trichomes bright blue-green, 7.5 to 8.5 μ, wide, markedly constricted at cell joints, end cell acute-conical; protoplasm granular.

Single specimen examined.—LUZON: Rizal: snow-white abundant growth with *S. alatum* on dry rocks in Montalban, 492, May 11, 1940 (PUH, PNH, FC).

SYMPLOCA PURPURASCENS Gomont. **Plate 6, figs. 84 and 84a.**

S. purpurascens GOMONT, Monogr. Oscill. (1893) 58, pl. 9, figs. 6–8.

Plant mass indefinitely expanded, violet blue-green; filaments dark purple, elongated, much interwoven, within firm highly lamellose sheaths that split towards the apices in some specimens; trichomes blue-green, usually 2 to 4 and far apart in a mother sheath, 6 to 8 μ wide, constricted at cell joints; cells long, protoplasm coarsely granular, apical cell conical.

Specimens examined.—PALAWAN: purplish blue-green growths in Tapun, 2895, June 20, 1951 (PUH, PNH, FC); also in Tapun, 2895a, June 20, 1951 (PUH, PNH, FC); 2892a, June 20, 1951 (PUH, PNH, FC).

Genus MICROCOLEUS Desmazieres, 1823

Plant frequently growing with other algæ in moist soil, generally in fresh water, at times in salt water; sheaths wide and colorless, never lamellose, diffluent in many species; trichomes within well-developed filaments are closely interwound into ropelike bundles, slightly tapering towards the apices; cells quadrate or elongate-cylindrical; apical cells acute, rarely obtuse-conical.

Key to the species of Microcoleus

1. Plant mass growing in salt water	2
1. Plant mass growing in fresh water	3
2. Trichomes 1.5 to 2 μ wide	*M. tenerrimus*
2. Trichomes 2.5 to 6 μ wide	*M. chthonoplastes*
3. Trichomes constricted	4
3. Trichomes not constricted	5
4. Trichomes markedly constricted, 4 to 5 μ wide	*M. lacustris*
4. Trichomes slightly constricted, 3.6 to 4 μ wide	*M. rupicola*
5. Apical cell very sharply acuminate	*M. accutissimus*
5. Apical cell not acuminate	6
6. Apical cell capitate, cells 3 to 7 μ long	*M. vaginatus*
6. Apical cell not capitate, cells 4 to 13 μ long	*M. paludosus*

MICROCOLEUS TENERRIMUS Gomont. **Plate 6, figs. 85 and 85a.**

M. tenerrimus GOMONT, Monogr. Oscill. (1893) 93, pl. 14, figs. 9–11.

Plant mass densely entangled, at times mixed with other algæ; trichomes 1.5 to 2 μ wide, blue-green, narrow, usually free in an open sheath attenuate into an acute-conical end cell; cell joints conspicuously constricted, protoplasm slightly granulated.

Single specimen examined.—LUZON: Pangasinan: dark blue-green growth that can withstand desiccation and is eaten by bañgos found on hardened mud in a fishpond, Alaminos, *E. Fenix 2*, October 7, 1928 (PUH, PNH, FC).

MICROCOLEUS CHTHONOPLASTES Thuret. **Plate 6, fig. 86.**

M. chthonoplastes THURET, Ann. Sci. Nat. 6e serie. Bot. 1 (1875) 378.

Plant mass compact, widely expanded, somewhat leathery, dark blue-green, growing with other algæ; trichomes 2.5 to 6 μ wide, bright blue-green, ordinarily numerous inside the thick, oftentimes open and roughened sheath, densely aggregated into bundles, sometimes twisted like cords; cells short and rectangular, with granular protoplasm; cell joints markedly constricted, end cell acute-conical, not thickened.

Specimens examined.—LUZON: Pangasinan: blackish blue-green growth floating as very thick mat on brackish water of fishpond in Dagupan, 230, December 30, 1930 (PUH, FC); Rizal: blackish blue-green growth on stones near artesian well in Navotas, 617, January 19, 1941 (PUH, PNH, FC); Manila: dark blue-green growth drying on edge of rice field along the side of highway in Singalong Subdivision, 241, December 31, 1939 (PUH, PNH, FC); dark blue-green growth on walls of street canal, Vito Cruz Subdivision, 421, February 4, 1940 (PUH, FC).

MICROCOLEUS LACUSTRIS Farlow. **Plate 6, figs. 87 and 87a.**

M. lacustres FARLOW in Farlow, Anderson, and Eaton, Algæ Exsic. Am. Bor., No. 227 bis! October 1877.

Stratum thin, ordinarily blue-green, dark blue-green among other algæ; trichomes 4 to 5 μ wide, numerous and parallel, sometimes twisted, forked in fascicles, bright blue-green and markedly constricted at cell joints; cells quadrate, with marked protoplasmic granulations; end cell acute-conical, not capitate.

Specimens examined.—LUZON: Laguna: deep blue-green growth along path of small lawn at Students' Mess Hall, Forestry Camp, Los Baños, 390, January 28, 1940 (PUH, PNH, FC); Pampanga: very fine blackish growth on very moist flat along the highway to Nursery in Arayat, 123, November 19, 1939 (PUH, PNH, FC, NY); Manila; greenish woolly growth on Padre Faura street, 92, November 12, 1938 (PUH, NH, FC, NY).

MICROCOLEUS RUPICOLA (Tilden) Drouet. **Plate 6, figs. 88 and 88a.**

M. rupicola (Tilden) DROUET, Field Mus. Nat. Hist. Bot. Sec. 20 (1943) 167.

Plant mass pale blue-green to blackish blue-green; trichomes grass-green, straight, many free from a diffluent easily destroyed sheath, phormidioid, constricted at cell joints, with conspicuous pairs of protoplasmic granules present in each cell; end cell rotund, others attenuate-conical.

Specimens examined. — LUZON: Bataan: deep blue-green growth with *P. autumnale* in Balanga, 2406, July 12, 1950 (PUH, PNH, FC). PANAY: Iloilo: dark blue-green extensive growth on damp soil in front of house of Mr. J. Estrella at Infanta street, Iloilo City, JDS, 1,000, June 20, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish deep blue-green floating or attached growth in Molawin Creek, Los Baños, *E. Quisumbing 77316*, October 13, 1929 (PUH, FC). LEYTE: very dull blue-green sunbaked curled masses on dried shallow depressions on lawn of Dulag Cathedral, Dulag, *M. E. Britton 111*, August 1, 1945 (PUH, PNH, FC). PALAWAN: in Araceli: deep blue-green growth, 2919, June 15, 1951 (PUH, PNH, FC); deep blue-green growth, 2929, June 15, 1951 (PUH, PNH, FC). LUZON: Pampanga: very fine blackish growth on very moist flat along the highway to Nursery in Arayat, 123, November 19, 1939 (PUH, FC); Rizal: dark blue-green growth on moist sidewalk along A. Flores street, Marikina, JDS, 966, May 22, 1952 (PUH, PNH, FC); dull blue-green growth at Dagat-dagatan, 625, January 19, 1941 (PUH, PNH, FC); Quezon City: on UP campus: dull blue-green growth in South 2nd street, Pav. 4, *M. B. Valero* and *G. T. Velasquez 138*, December 5, 1955 (PUH, PNH, FC); dark blue-green growth, 2515, February 28, 1950 (PUH, PNH, FC).

MICROCOLEUS ACCUTISSIMUS Gardner. Plate 6, figs. 89 and 89a.

M. accutissimus GARDNER, Mem. New York Bot. Gard. 7 (1927) 55, pl. 11, fig. 2.

Plant mass blue-green, sometimes black, lead or ash-colored; trichomes 1.8 to 2.2 μ wide, evidently blue-green, sometimes purplish, numerous, compact and almost parallel, rarely twisted into a cord within a closed sheath which opens at maturity; sheaths usually colorless, thick and diffluent; cells quadrangular, very slightly constricted at joints, with finely granulated protoplasm; apical cell acute-conical, slightly thickened.

Specimens examined.—PANAY: Iloilo: deep greenish-black growth with *S. Hofmannii* on moist interior walls exposed to sun and rain in ruins of Catholic Church in Passi, JDS, 1071, July 20, 1952 (PUH, PNH, FC). MINDORO: Oriental Mindoro: ash-colored growth on cliffs above high tide from west part of

Muelle, Puerto Galera, 723, March 31, 1941 (PUH, FC). LUZON: Manila: dark blue-green growth along sidewalk of Pennsylvania street, 101, November 18, 1939 (PUH, PNH, FC).

MICROCOLEUS VAGINATUS Gomont. Plate 5, figs. 90 and 90a.

M. vaginatus GOMONT in Morot, Jour. Bot. 4 (1890) 353.

Plant mass blackish to greenish blue-green, hard when dry; trichomes 3.5 to 7 μ wide, pale blue-green, subparallel or slightly twisted, many free from diffluent sheaths, not constricted at cell joints; protoplasm granular; apical cell depressed conical with much thickened membrane.

Specimens examined.—LUZON: Bulacan: blackish luxuriant growth behind bath room of L. J. Cabral's house in Calumpit, 426, February 4, 1940 (PUH, FC). PANAY: Iloilo: dull dark blue-green growth on moist soil near Sta. Rita Hall, San Augustin College, Iloilo City, JDS, 1007, June 20, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish dark blue-green growth on bamboo rafts in Sampaloc Lake, San Pablo City, 682, February 9, 1941 (PUH, PNH, FC). LEYTE: dull blue-green layer on mud in drainage from shower room one mile west of Palo, *M. E. Britton 167*, November 26, 1945 (PUH, FC). LUZON: Mountain Province: in Baguio: dark blue-green growth with *P. autumnale, M. paludosus*, and *P. calidum* on dry side of embankment along Leonard Wood Road, 214a, December 28, 1939 (PUH, FC); blackish growth on roadside near Pines Hotel, 191, December 28, 1939 (PUH, FC); blackish papery growth on wood at Bureau of Public Works Cottage, 193, December 28, 1939 (PUH, FC); blackish growth on moist surface of a highway canal, 197, December 27, 1939 (PUH, PNH, FC); Pampanga; dark blue-green growth on soil kept constantly moist by water from a dripping pipe at a nursery in Arayat, 513, May 22, 1940 (PUH, FC); Rizal: dark blue-green growth on surface of a dry pond in Montalban, 497, May 1, 1940 (PUH, FC); blackish deep blue-green growth with *P. calidum, O. acuminata*, and *O. brevis* on wet stones near artesian well in Dagat-dagatan, 622, January 19, 1941 (PUH, FC); Manila: forming a dark blue-green growth with *M. paludosus, M. subtorulosa*, and *P. calidum* on somewhat green moist soil along Oregon street, 137, November 22, 1939 (PUH, PNH, FC); deep blue-green growth along pedestrian path at Vito Cruz Subdivision, *F. Salas* and *G. T. Velasquez 420*, February 4, 1940 (PUH, PNH, FC).

MICROCOLEUS PALUDOSUS Gomont. Plate 7, figs. 91 and 91a.

M. paludosus GOMONT, Monogr. Oscill. (1893) 96, pl. 14, fig. 13.

Plant mass much entangled and dirty, growing with other algæ, lead colored or dark blue-green to light blue-green; trichomes 5 to 7 μ wide, bright blue-green, numerous, separate or evidently fascicled, intertwined into cords in an open, sometimes closed dirty gelatinous sheath; protoplasm granular; apical cell rotund or conical, sometimes acute-conical, not capitate in many specimens.

Specimens examined.—LUZON: Bataan: dark blue-green growth in Sta. Rosa, 2409, July 13, 1950 (PUH, PNH, FC). PANAY: Iloilo: dark blue-green growth on moist soil in front lawn of Cabatuan High School, *JDS 1104*, November 16, 1952 (PUH, PNH, FC). PALAWAN: deep blue-green growth, in Babuyan, 2910, June 20, 1951 (PUH, PNH, FC); all in Cuyo: deep blue-green 2849, June 9, 1951 (PUH, PNH, FC); deep blue-green growth, 2809, June 10, 1951 (PUH, PNH, FC); deep blue-green growth, 2820, June 11, 1951 (PUH, PNH, FC); deep blue-green growth in Iwahig Penal Colony, 2878, June 18, 1951 (PUH, PNH, FC); dark blue-green growth with *S. Hofmannii* in Puerto Princesa, 2910a, June 20, 1951 (PUH, PNH, FC). LUZON: Rizal: dark blue-green growth on damp soil in church yard at Bo. Santolan, Pasig, JDS, May 30, 1952 (PUH, PNH); Quezon City: on UP campus: dark blue-green growth, 2449, June 28, 1950 (PUH, PNH, FC); dark blue-green growth, 2456, July 29, 1950 (PUH, PNH, FC).

Genus HYDROCOLEUM Kutzing, 1843

Filaments usually forming a cushion of indefinite growth in salt water; trichomes solitary and flexuous, sometimes two or three found in a colorless oftentimes lamellose sheath; cells generally capitate.

Key to the species of Hydrocoleum

1. Filaments growing in tufted masses 2
1. Filaments growing as mucilaginous masses .... *H. glutinosum*
    2. Sheaths irregular, becoming blackish green 3
    2. Sheaths regular, cylindrical, becoming violet ...... *H. comoides*
3. Trichomes 18 to 24 μ wide .... *H. cantharidosmum*
3. Trichomes 8 to 16 μ wide .... *H. lyngbyaceum*

HYDROCOLEUM GLUTINOSUM Gomont. Plate 7, fig. 92.

H. glutinosum GOMONT in Morot, Jour. Bot. 4 (1890) 353.

Filaments purplish blue-green, sometimes yellowish, loosely entangled, not caespitose, widely expanded; trichomes 14 to 21 μ wide, blue-green to light purplish within a mucoid, gelatinous dirty sheath, tapering towards the apex and not constricted at cell joints; protoplasm granular; end cell truncate.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: yellowish blue-green growth on mud-covered bases of old *Vallisneria* leaves submerged even during low tide at Hondura Bay, 919, April 12, 1941 (PUH, FC); purplish blue-green to yellowish brown growth in West Muelle, 1855, April 25, 1949 (PUH, PNH, FC); yellowish-purple growth in West Paniquian, 1904, April 29, 1949 (PUH, PNH, FC).

HYDROCOLEUM COMOIDES Gomont.

H. comoides GOMONT, Monogr. Oscill. (1893) 73, pl. 12, figs. 3–5.

Filaments long, substraight, parallel, lyngbyaceous; trichomes somewhat rich blue-green, 14 to 21 μ wide, wtihin thick lamellose cylindrical sheaths, gently tapering and constricted at cell joints; cells short, with granular protoplasmic contents; end cell truncate, not thickened.

Specimens examined.—BABUYAN ISLANDS: light blue-green growth in Calayan Island, *R. C. McGregor 25*, November, 1903 (PUH, FC). LUZON: Pangasinan: dull blue-green growth on coralline stones in Alaminos, *E. Fenix 22*, October 7, 1928 (PUH, PNH, FC).

HYDROCOLEUM CANTHARIDOSMUM Gomont. Plate 7, fig. 93.

H. cantharidosmum GOMONT in Morot, Jour. Bot. 4 (1890) 353.

Filaments long, somewhat parallel, substraight, deep blue-green to purplish blue-green in other specimens; trichomes 18 to 24 μ wide, usually loose, light blue-green, inside irregular, often torn, hyaline, gelatinous and lamellose sheaths; not constricted at cell joints and lightly tapering towards apex, cells very short, with finely granular protoplasm; end cell truncate, not thickened.

Specimens examined.—Albatross Expedition: CAMIGUIN: purplish-brownish yellow growth, *R. C. McGregor*, 124, July, 1907 (PUH, UC). MINDORO: Oriental Mindoro: in Puerto Galera: purplish blue-green growth drifting along the shore of Ensenada, Hondura Bay, *Elsie Uy* and *G. T. Velasquez 923*, April 15, 1941 (PUH, FC); pale blue-green growth in first Plateau, 1718, April 23, 1948 (PUH, PNH, FC); purplish deep blue-green growth in first Plateau, 1842, April 20, 1949 (PUH, PNH, FC, NY, UC); dark blue-green growth at Farola Point, 1934, May 21, 1949 (PUH, PNH, FC, NY, UC).

HYDROCOLEUM LYNGBYACEUM Kutzing. Plate 7, fig. 94.

H. lyngbyaceum KÜTZING, Sp. Alg. (1849) 259.

Plant mass ordinarily thin, growing with other algæ in many collections, purplish blue-green or dull to bright blue-green; trichomes widely expanded within conspicuous, mucoid sheath, tapering and not constricted at cell joints; cells short, protoplasm granular, end cell truncate.

Specimens examined. — BABUYAN ISLANDS: all in Calayan Island: light blue-green growth, *R. C. McGregor 20*, November, 1903 (PUH, PNH, FC); pale blue-green growth on one of the Gorgonidæ, *R. C. McGregor 46*, 1903 (PUH, PNH, FC); blue-green growth on coral limestone near shore, *R. C. McGregor 50*, September 30, 1903 (PUH, PNH, FC, NY). MINDORO: Oriental Mindoro: all in Puerto Galera: growing on decaying logs along the shore submerged during high tide at West Muelle, 721, March 31, 1941 (PUH, PNH, FC, NY); growing with *Lyngbya majuscula* on sandy part of shore at Medio Island, 902, April 17, 1941 (PUH, PNH, FC, NY); pale yellowish-green growth in Muelle, 1680, April 30, 1948 (PUH, PNH, FC, NY, UC); yellowish blue-green growth in East Medio Island, 1707, April 20, 1948 (PUH, PNH, FC, NY, UC).

Family NOSTOCACEÆ

The sheaths are variable, very often not clearly present in many species, distinctly gelatinous and membranaceous in others; trichomes not branched, composed of a single row of generally uniform cells with conspicuous heterocysts, reproduction by hormogones and akinetes.

Key to the genera

1. Sheaths not readily conspicuous, diffluent, or gelatinous and thick in some specimens 2
1. Sheaths readily conspicuous, filaments in a parallel manner 4
    2. Trichomes contorted forming a colonial mass of definite shape. *Nostoc*
    2. Trichomes more or less straight, forming thin mucous layers of indefinite shape 3
3. Cells uniform, oftentimes barrel-shaped, heterocysts and akinetes intercalary .... *Anabæna*
3. Cells not uniform, barrel-shaped to much elongated, akinetes contiguous to basal heterocysts .... *Cylindrospermum*

   4. Trichomes single within the sheath, heterocysts and akinetes intercalary .... *Aulosira*
   4. Trichomes usually many within the sheath, akinetes unknown. *Hormothamnion*

Genus NOSTOC Vaucher, 1803

Plants generally colonial, at first globose, later developing into various forms in different species, solid or hollow as gelatinous or leathery irregular masses floating or lying free on moist grassy habitats; each colony is made of almost sheathless trichomes in many species, usually closely associated to form variously curved entangled filaments; trichomes usually chainlike, cells spherical, depressed-spherical, barrel-shaped or cylindrical; heterocysts intercalary, conspicuous by being generally larger and forming empty cells; akinetes globular or oblong.

Key to the species of Nostoc

1. Trichomes up to 4 μ wide 2
1. Trichomes 4 μ or more wide 11
   2. Cells usually cylindrical, when shorter barrel-shaped 3
   2. Cells generally spherical or depressed-spherical 6
3. Cells oblong-cylindrical or cylindrical 4
3. Cells generally barrel-shaped to cylindrical 5
   4. Oblong-cylindrical cells generally twice longer than wide, short elliptical spores 6 μ wide and 8 to 10 μ long. .... *N. carneum*
   4. Cylindrical cells much longer than wide, long elliptical spores 6 to 8 μ wide and 14 to 19 μ long .... *N. ellipsosporum*
5. Cells invariably barrel-shaped to cylindrical, oblong spores in catenate series .... *N. Muscorum*
5. Cells evidently barrel-shaped, spores not seen .... *N. cuticulare*
   6. Trichomes always narrow, never reaching 4 μ wide 7
   6. Trichomes always reaching 4 μ wide 9
7. Trichomes up to 3 μ wide, cells usually spherical, spores nearly globular 8
7. Trichomes 3 to 3.5 μ wide, cells spherical-depressed and closely connected, spores oval .... *N. verrucosum*
   8. Trichomes up to 2.5 μ wide .... *N. calcicola*
   8. Trichomes generally wider, reaching 3 μ .... *N. humifusum*
9. Globose spores especially in long catenate series .... *N. piscinale*
9. Globose to subglobose spores not in long catenate series 10
   10. Spores imperfectly matured, 6 to 8 μ in diameter. *N. maculiforme*
   10. Spores imperfectly matured, 6 to 7 μ wide and 7 to 8 μ long. . *N. Linckia*
11. Cells generally depressed-spherical, spores not observed 12
11. Cells almost spherical to briefly oblong, spores observed 13
   12. Heterocysts globular, 3 to 5 in a series .... *N. commune*
   12. Heterocysts subglobular, single .... *N. pruniforme*

13. Globular heterocysts larger, 7 μ in diameter ...... *N. microscopicum*
13. Oblong heterocysts smaller, 5 to 6 μ average diameter .... *N. rivulare*

NOSTOC CARNEUM Agardh. Plate 7, fig. 95.

N. carneum AGARDH, Syst. Alg. (1824) 22.

Plant mass at first globose, becoming bullate-tuberculate, floating or attached, deformed when mature, irregularly expanded, diffluent, blue-green; filaments loosely interwoven, moderately flexuous; sheaths not distinct, hyaline; trichomes 3.5 to 4 μ wide, cells generally oblong-cylindrical, sometimes depressed-globose; heterocysts oblong, 6.0 μ in diameter; spores oval to elliptic, (8 to 10) 8.5 μ long and (6) 5.4 μ wide, with smooth walls, distant from each other.

Specimens examined.—PANAY: Iloilo: collected in Iloilo, *Bur. Sci. 18122 C. B. Robinson,* January 1 to 11, 1913 (PUH, FC). LUZON: Laguna: blue-green growth in Los Baños, *Bur. Sci. 77314 E. Quisumbing,* October 13, 1929 (PUH, PNH, FC). MINDORO: Oriental Mindoro: blue-green growth on a pond in Big Tabinay, Puerto Galera, 931, April 7, 1941 (PUH, PNH). LUZON: Quezon City: grayish blue-green growth in Balara, 2484, March 13, 1949 (PUH, PNH, FC).

NOSTOC ELLIPSOSPORUM Rabenhorst. Plate 7, fig. 96.

N. ellipsosporum RABENHORST, Flora Europ. Algar. 2 (1865) 169.

Thallus attached, expanded, gelatinous, irregularly mamillose, dark brown-yellow; filaments flexuous, loosely interwoven; trichomes (4.0) 3.5 to 6 μ wide; pale blue-green to olive; cells cylindrical, (6–) 9 to 14 μ long; heterocysts subspherical to oblong, 6 to 11.9 (–14) μ long and 6 to 7 μ wide; spores in series, hyaline to yellowish, (14–) 11.9 to 19 μ long and 6 to 8 μ wide, with smooth wall.

Specimens examined.—LUZON: Ilocos Norte: dark blue-green to yellowish-brown mucilaginous mass floating in Cabalayangan Cove, Nueva Era, 3636, April 15, 1955 (PUH, PNH, FC). MINDORO: Oriental Mindoro: blackish blue-green growth in Aguada, Puerto Galera, 1843, April 21, 1949 (PUH, PNH, FC, NY). LUZON: Rizal: dark yellowish-brown growth with *N. commune* at foot of stone stairs to Hinulugan Taktak, Antipolo, 685, January 25, 1941 (PUH, PNH); blackish growth on grassy moist sidewalk at Bo. Lanka, Marikina, JDS, May 27, 1952 (PUH, PNH, FC); Manila in UP Botanical Garden: dark greenish black growth with *Gloeothece rupestris* on tank, 659, November 26, 1940 (PUH, PNH, FC); growing on tank, 467, February

29, 1940 (PUH, PNH, FC); Quezon City: on UP campus: blackish blue-green growth, 2426, July 22, 1950 (PUH, PNH, FC); dark blue-green to yellowish brown growth, 2446, July 27, 1950 (PUH, PNH, FC); blue-green growth with *S. Muscorum*, 2453, July 28, 1950 (PUH, PNH, FC).

NOSTOC MUSCORUM Agardh. **Plate 7, fig. 97.**

N. Muscorum AGARDH, Disp. Alg. Succ. (1812) 44.

Plant mass gelatinous, membranaceous, irregularly expanded and tuberculate, deep blue-green to olive-yellow, attached or floating when matured; filaments flexuous, densely interwoven; trichomes 3.0 to 4:5 (–4) μ wide, cells spherical, doliform to cylindrical; heterocysts subglobose to oval, (6–) 5.5 to 7.2 (–7) μ wide; spores oblong, in catenate series, numerous, (8–) 9 to 12 μ long and (4–) 6.0 to 6.8 (–8) μ wide, with smooth walls.

Specimens examined.—BATAN: dark blue-green growth in Panilao, 2413, July 13, 1950 (PUH, PNH, FC, NY). LUZON: Batangas: in Lipa City: dark blue-green growth along the muddy bank of Balete River, 597, January 12, 1941 (PUH, PNH, FC): dark blue-green growth on muddy flat along Balete River, 297a, January 12, 1941 (PUH, FC). PANAY: Capiz: blackish blue-green growth on moist sidewalk beside town plaza, Ivisan, JDS, 1511, November 30, 1952 (PUH, PNH, FC). LUZON: Ilocos Norte: blue-green growth on moist soil, west of resthouse, Banna, 2233, June 5, 1950 (PUH, PNH, FC); yellowish blue-green to purplish blue-green growth on moist bank of road to river, Piddig, 2252, June 7, 1957 (PUH, PNH, FC). LEYTE: blue-green growth forming dried stratum on soil near Tanauan, *M. E. Britton 117*, August 3, 1945 (PUH, FC). MINDORO: Oriental Mindoro: dark blue-green growth on saturated surface growing with grasses at poblacion, 1134, May 9, 1941 (PUH, PNH). LUZON: Pampanga: in Arayat: dark blue-green growth on very moist soil along highway to Nursery, 124, November 19, 1939 (PUH, PNH, FC); bluish-green coating on wet muddy flat along the highway to the nursery, 118, November 19, 1939 (PUH, PNH, FC). PALAWAN: in Aborlan: olivaceous-green to blue-green growth, 2854, June 17, 1951 (PUH, PNH, FC); blackish blue-green growth, 2854a, June 17, 1951 (PUH, PNH, FC); dark blue-green growth, 2855, June 17, 1951 (PUH, PNH, FC); blue-green to blackish blue-green growth, 2860, June 17, 1951 (PUH, PNH, FC); deep blue-green growth in Coron, 2782, June 3, 1951 (PUH, PNH, FC); deep blue-green growth in

Cuyo, 2800, June 10, 1951 (PUH, PNH, FC, NY); blue-green to almost black growth in Iwahig Penal Colony, 2880, June 18, 1951 (PUH, PNH, FC, NY). LUZON: Rizal: blue-green growth on a shallow stream leading to Hinulugan Taktak, Antipolo, 686, January 25, 1941 (PUH, PNH, FC); yellowish blue-green growth in a cyperus canal, Las Piñas, 3707, December 28, 1955 (PUH, PNH, FC); dark blue-green growth on standing water in rice paddy at Bo. Santolan, Marikina, JDS, 987, May 30, 1952 (PUH, PNH, FC); blue-green growth in a wet canal along the highway, New Manila, 179, December 13, 1939 (PUH, PNH, FC); Quezon City: in Balara: deep blue-green growth 2482, March 13, 1949 (PUH, PNH, FC); dark yellowish-brown growth, 2557, August 26, 1950 (PUH, PNH, FC); all on UP campus: yellowish-green to blue-green growth, 2429, July 22, 1950 (PUH, PNH, FC); dark blue-green growth, 2524, February 28, 1928 (PUH, PNH, FC, NY).

NOSTOC CUTICULARE Bornet and Flahault. Plate 7, fig. 98.

N. cuticulare BORNET and FLAHAULT in Ann. Sci. Bot. 7 (1888) 187.

Thallus adnate, thin and orbicular, confluent, bright blue-green; filaments contorted, densely entangled to form masses; sheaths distinct, gelatinous, hyaline; trichomes 3.8 to 4 μ wide, blue-green, often gelatinizing until they clump close together; cells short, barrel-shaped; heterocysts little larger than vegetative cells, equally barrel-shaped; spores not seen in the single specimen examined.

Single specimen examined.—MINDORO: Oriental Mindoro: blue-green growth on submerged coconut leaves, Puerto Galera, 1847, April 23, 1949 (PUH, PNH, FC, NY, UC).

NOSTOC VERRUCOSUM Vaucher. Plate 7, fig. 99.

N. verrucosum VAUCHER, Hist. Conf. Douce (1803) 225, pl. 16, fig. 3 a-d.

Thalli especially gregarious, blue-green, solid when young, nearly globose and floating on stagnant water in maturity, firm and hard on drying; filaments flexuous, contorted, densely interwoven; sheaths thick, indistinctly hyaline, yellowish; cells of trichomes globose to subglobose, up to 4.5 μ in diameter; heterocysts generally spherical, larger than vegetative cells; spores not seen.

Single specimen examined. — MINDORO: Oriental Mindoro: dull yellowish blue-green growth floating on stagnant water at Big Balatero, Puerto Galera, 1699, May 14, 1948 (PUH, PNH, FC, NY, UC).

NOSTOC CALCICOLA Brebisson. Plate 8, fig. 100.

N. calcicola BREBISSON in Meneghini, Monogr. Nost. Ital. (1843) 121.

Thallus mucoid, diffluent, expanded, blue-green; filaments somewhat flexuous, loosely interwoven; trichomes 2.5 μ wide, pale blue-green, within thin sheaths; cells subspherical, or barrel-shaped generally 2.5 μ in diameter; heterocysts 4 (–5) μ wide; spores globose, 4 to 5 μ long and 3 to 4 μ wide.

Single specimen examined.—PANAY: Iloilo: dark blue-green growth on moist soil on the yard of the house of Atty. S. Catillano, San Pedro St., JDS, 1030, June 23, 1952 (PUH, PNH, FC, NY).

NOSTOC HUMIFUSCUM Carmichael. Plate 8, fig. 101.

N. humifuscum Carmichael Sec. HARVEY in Hooker's Brit. Fl. 2 (1833) 399.

Plant mass gelatinous, olive-green forming an irregular growth of variable sizes among other groups of algæ, expanding on maturity and becoming tuberculate; filaments densely woven, contorted flexuous; sheath not distinct, trichomes fine, (2.2–) to 2.5 to 3.3 (–3) μ wide, blue-green; cells subglobose, spherical, cell diameter increasing to twice than ordinary; heterocysts (3) 3.6 μ wide, oval to subspherical; spores generally oval, 6 μ long and 4 μ wide.

Specimens examined.—LUZON: dark blue-green growth submerged in water on a grassy field at Mandaluyong, 174, December 10, 1939 (PUH, PNH, FC); thin blackish growth on dry soil of embankment of river in Marikina, 411, February 2, 1940 (PUH, FC).

NOSTOC PISCINALE Kutzing. Plate 8, fig. 102.

N. piscinale KÜTZING, Phycol. Gener. (1843) 208.

Plant mass globose, in gelatinous masses, tuberculate, blue-green to pale yellow; filaments flexuous, moderately interwoven; sheaths distinct, yellowish, hyaline; trichomes (4) 3.4 to 4.0 μ wide, olive to light blue-green; cells spherical to subspherical; spores globose, in catenate series, 6 to 7 μ in diameter.

Specimens examined.—LEYTE: small blue-green gelatinous masses floating in depressions of lawn at Palo Cathedral, Palo, *M. E. Britton 108,* July 25, 1945 (PUH, PNH, FC); grass-green gelatinous masses floating on small pond one mile southwest of Palo, *M. E. Britton 109,* July 25, 1945 (PUH, PNH, FC); pale blue-green gelatinous material floating or submerged in almost transparent streams extending to bottom of shallow roadway ruts collected one mile west of Palo, *M. E. Britton 173,* November 26, 1945 (PUH, PNH, FC).

NOSTOC MACULIFORME Bornet and Flahault. Plate 8, fig. 103.

N. maculiforme BORNET and FLAHAULT in Ann. Sci. Bot. VII 7 (1888) 189.

Plant mass flat and thin, attached, blue-green; filaments flexuous, contorted, slightly agglutinated, loosely interwoven; sheaths distinct, yellowish when matured; trichomes (3.5–) to 3–4 μ wide; cells oblong and spherical-depressed; spores globose, in catenate series, 6 to 7 (–8) μ wide, with smooth wall.

Single specimen examined.—MINDORO: Oriental Mindoro: blue-green growth in Puerto Galera, 1698, May 14, 1948 (PUH, PNH).

NOSTOC LINCKIA Bornet. Plate 8, fig. 104.

N. Linckia BORNET in Bornet et Thuret, Notes algol. 2 (1800) 86, pl. 28, figs. 1–12.

Plant mass of various sizes, globose or spread and irregularly torn, gelatinous, light violet to blue-green, growing with other algæ; filaments flexuously contorted or bent; sheaths hyaline; trichomes (3.5–) 3 to 4 μ wide, blue-green; cells spherical-depressed; heterocysts (5–) 4.5 to 5.5 (–6) μ wide, subspherical; spores 7 to 7.6 (–8) μ long and (6–) 5.5 to 6.5 (–7) μ wide.

Specimens examined. — LUZON: Ilocos Norte: bright blue-green growth floating on a more or less slow-moving stream, on western river side of Laoag, 3616, April 19, 1955 (PUH, PNH, FC, NY); blue-green growth floating with other algæ along the shore or lagoon, Gabu, 2659, April 6, 1955 (PUH, PNH).

NOSTOC COMMUNE Vaucher. Plate 8, fig. 105.

N. commune VAUCHER, Hist. Conf. Douce (1803) 222, pl. 16, fig. 1a-e.

Thalli gelatinous, firm, at first globose, becoming applanate and deformed on maturity, oftentimes irregularly flat, wavy, pannose and membranaceous, light green, becoming black and hard when dried; filaments very flexuous, loosely circinate; sheaths transparent and hyaline; trichomes 4.5 to 6 μ wide; cells spherical-depressed to barrel-shaped; heterocysts 7 μ wide, subspherical; spores not seen.

Specimens examined.—BANTAYAN ISLANDS: yellowish blue-green growth, *R. C. McGregor 116*, September, 1906 (PUH, FC). LUZON: Ilocos Norte: in Banna: blackish blue-green growth on moist sidewalk near resthouse, 2228, June 5, 1950 (PUH, PNH, FC); yellowish blue-green to black growth on moist soil among grasses beside river, 2265, June 9, 1950 (PUH, PNH, FC, NY); in Nueva Era: yellowish-brown to almost black growth on the exterior side of the concrete water reservoir near Cabalayangan Creek, 3628, April 15, 1955 (PUH, PNH, FC, NY); brownish subærial growth, sometimes with mucilaginous patches growing on moist exterior sides of cemented water tank, 3637, April 15, 1955 (PUH, PNH, FC); in Piddig: yellowish dark blue-green growth on moist bank of river, 2255, June 7, 1950 (PUH, PNH, FC); yellowish dark blue-green growth on stagnant pool of river, 2251, June 7, 1950 (PUH, PNH, FC). PALAWAN: yellowish brown to black growth in Araceli, 2940, June 15, 1951 (PUH, PNH, FC, NY); in Cuyo: greenish-brown to almost black growth, 2806, June 10, 1951 (PUH, PNH, FC); dark blue-green to brownish black growth, 2836, June 12, 1951 (PUH, PNH, FC, NY).

NOSTOC PRUNIFORME Agardh. Plate 8, fig. 106.

N. pruniforme AGARDH, Disp. Alg. Suec. (1912) 45.

Plant mass ovoid, as large as a hen's egg, olive-yellow, coriaceous towards periphery; filaments loosely interwoven; sheaths distinct and hyaline, yellowish; trichomes (4–) 4.5 to 6 μ wide; cells globose-compressed, barrel-shaped, coarsely granulated; heterocysts globose to subglobose, 6 to 7 μ wide; spores not seen.

Single specimen examined.—LUZON: Mountain Province: growing in rice fields, Banco, Bontoc, Father Morice Vanoverbergh, October 1, 1910 (PUH, FC).

NOSTOC MICROSCOPICUM Carmichael. Plate 9, fig. 107.

N. microscopicum CARMICHAEL ex HARVEY in Hooker's Brit. Fl. 5 (1833) 399.

Plant mass globose to oblong, growing with other algæ, moderately large up to nearly a centimeter in diameter, olive blue-green, sometimes yellowish; filaments loosely interwoven, sometimes assuming a zigzag form; sheaths distinct, gelatinous, usually yellowish; trichomes 5 to 7.5 (–8) μ wide, blue-green; cells subglobose, barrel-shaped; heterocysts generally

7 μ wide, subspherical; spores (9–) 10 to 12 (–15) μ long and (6 to 7) generally 6.7 μ wide.

Specimens examined.—LUZON: Mountain Province: growing with *Marchantia* near Pines Hotel in Baguio, 192, December 26, 1939 (PUH, PNH, FC). MINDORO: Oriental Mindoro: on trunk of coconut palm, near the source of water supply, Puerto Galera, 727, April 2, 1941 (PUH, PNH, FC).

NOSTOC RIVULARE Kutzing. Plate 9, fig. 108.

N. rivulare KÜTZING. Tab. Phycol. 2 (1850–1852) 3, pl. 10, fig. 3.

Thalli usually globose, of variable sizes, bullate-tuberculate, irregularly cut, fragile, at first brilliant green, becoming blue-green, then light yellow; filaments loosely interwoven, moderately flexuous; sheaths thick and distinct, yellow to hyaline; trichomes (4–) 3.5 to 4.5 (–4.2) μ wide, cells usually spherical, oblong, with granular contents; heterocysts oblong, (5–) 4.5 to 6 μ wide; spores oblong, in catenate series, (7–) 8.5 to 10 μ long and (6–) 6.5 to 7.7 (–8) μ wide, smooth, yellow or hyaline.

Specimens examined.—LUZON: Pampanga: deep blue-green growth floating on the shallow side of running water at Nursery, Arayat, 114, November 19, 1939 (PUH, PNH, FC); Pangasinan: growing on pond near the railroad at Dagupan, December 30, 1939 (PUH, PNH, FC).

There are numerous species under the genus *Nostoc* which can be put together under fewer groups based on the following characters:

1. The character of colonial formation.
2. Spherically compressed, barrel-shaped to more elongated vegetative cells.
3. Accompanying heterocysts are globose to oblong, which generally need only one measurement for the width.
4. The arrangement of the spores is sngle or catenate and usually oval in shape.

Genus ANABÆNA Bory, 1822

Plants generally forming floccose colonies in fresh-water and in moist places; trichomes loosely flexuous, seldom showing evident sheath, generally having the same diameter throughout the entire length; intercallary heterocysts regularly numerous and conspicuous; cells usually barrel-shaped, slightly tapering towards the apices: akinetes variable in size and form singly or in catenate series.

Key to the species of Anabæna

1. Spores spherical, oval or ellipsoidal 2
1. Spores cylindrical 4
    2. Spores solitary, always adjacent to heterocysts .... *A. unispora*
    2. Spores in series, remote or adjacent to heterocysts 3
3. Spherical to broadly oval, in short series adjacent to heterocysts. *A. sphærica*
3. Usually narrow-oval, in long series remote to heterocysts. *A. variabilis*
    4. Spores up to 22 μ long, solitary and in series adjacent to heterocysts .... *A. oscillarioides*
    4. Spores up to 15.3 μ long, usually two in series remote to heterocysts. .... *A. inæqualis*

ANABAENA UNISPORA Gardner. Plate 9, fig. 109.

A. unispora GARDNER, Mem. New York Bot. Gard. 7 (1927) 59, pl. 12, fig. 8.

Stratum generally floating or somewhat submerged, blue-green, mucoid, trichomes intermixed with other algæ, agglutinated, (–4) 4.8 to 5.5 (–4.5) μ wide, slightly tapering towards the apices; cells cylindrical, sometimes short, subspherical, truncate; end cell blunt, slightly conical; heterocysts 10.2 μ long and 6 to 8 μ wide, generally oblong; spores solitary, ellipsoidal or ovoid, (20–) 27.2 to 34 μ long, (13–) 15 to 17 (–20) μ wide, adjacent to one side of the heterocyst.

Specimens examined. — LUZON: Ilocos Norte: blue-green growth on quiet side of river, Banna, 2262, June 9, 1950 (PUH, PNH, FC); Rizal: blue-green growth floating or attached to submerged grasses in a small pond at Limnological Station, Tanay, 439, February 9, 1940 (PUH, FC).

ANABAENA SPHAERICA Bornet and Flahault. Plate 9, fig .110.

A. sphærica BORNET and FLAHAULT in Ann. Sci. Bot. VII 7 (1888) 228.

Plant floccose, rich blue-green; trichomes (5–) 5.1 to 6.1 (–6) μ wide, straight, parallel, agglutinated; sheaths not distinct; cells spherical-truncate, oblong; heterocysts (6–) 6.4 to 7.6 (–7) μ wide, globose to oblong; spores spherical to subovoid, (12–) 17 to 20.4 (–18) μ long, 12 to 13.6 μ wide; contiguous to heterocysts, smooth outside wall.

Spores of the specimens examined are extraordinarily large.

Specimens examined. — LUZON: Pampanga: blue-green growth with *Anabæna torulosa* growing on very moist soil at Nursery, Arayat, 122, November 19, 1939 (PUH, FC); Rizal: submerged or floating mucilaginous blue-green colonial form, Mandaluyong, 163, December 10, 1939 (PUH, PNH, FC); Manila: blue-green floating or suspended in water of street canal, Vito Cruz Subdivision, 548, August 24, 1940 (PUH, FC).

ANABAENA VARIABILIS Kutzing. Plate 9, fig. 111.

A. variabilis KÜTZING, Phycolog. Gener. (1843) 210.

Plant expanded, free floating or on surface of moist path or soil, brilliant blue-green to dark green; trichomes generally flexuous, parallel in part, (4.3–) 3.4 to 5.1 (–5) μ wide; cells rarely barrel-shaped, generally up to 4.3 μ long, subquadrate; constricted at the joints; heterocysts in series, spherical-oval, 5 to 6 μ long, somewhat truncate at the apex; spores in catenate series remote to heterocysts, oval and truncate at the apices, (8–) 8.5 to 13.6 (–14) μ long and (7 to 9) generally 6.8 μ wide.

Specimens examined—PANAY: Iloilo: dark blue-green growth on moist soil in front of no. 55 Mabini street, Lambunao, *JDS 1901*, August 3, 1953 (PUH, PNH, FC). LEYTE: grass-green gelatinous masses with bright green surfaces that are pebbly-appearing due to air bubbles, floating on small grassy pool near coral pit, Tacloban, *M. E. Britton 155*, October 10, 1945 (PUH, PNH, FC). LUZON: Manila: deep blue-green growth on path along the street at Pandacan, 569, August 10, 1940 (PUH, FC).

ANABAENA OSCILLARIOIDES Bory. Plate 9, fig. 112.

A. oscillarioides BORY, Dict. Class d'Hist. Nat. (1822) 308.

Stratum gelatinous, deep green; trichomes (4.2–) 3.7 to 4 (–6), μ wide, cells doliriform, heterocysts spherical to cylindrical, spores ovoid when young, becoming cylindrical on maturity, 20 to 22 (–40) μ long and (8–) 7.7 to 11.0 (–10) μ long and (8–) 7.7 to 11.0 (–10) μ wide.

Specimens examined.—LUZON: Batangas: blackish growth on moist flat of Balete River, Lipa, 368, January 21, 1940 (PUH, FC. LEYTE: dark green growth on bottom of small pool at airstrip near Tacloban, *M. E. Britton 81*, July 4, 1945 (PUH, FC). MINDORO: Oriental Mindoro: blue-green growth on moist part of bank of fresh-water stream at Big Balatero, Puerto Galera, 946, April 22, 1941 (PUH, PNH, FC).

ANABAENA INEQUALIS Bornet and Flahault. Plate 9, fig. 113.

A. inequalis BORNET and FLAHAULT in Ann. Sci. Bot. VII. 7 (1888) 231.

Stratum submerged when young, floating on maturity, blue-green; trichomes (4 to 5) generally 4.8 μ wide, straight, held together usually by a mucoid substance, with distinct sheaths, cells truncate-spherical, tapering towards the apices, and ending in an obtuse apical cell; heterocysts 5.9 μ wide, globose to oblong; spores 2 to 3 in a series, remote from heterocysts, (14–) 10.2 to 15.3 (–17) μ long and (6–) 5.7 to 6 (–8) μ wide.

Specimens examined.—LUZON: Batangas: blue-green growth with spores of *A. variabilis* submerged in Balete River, Lipa, 370, January 21, 1940 (PUH, PNH, FC); Quezon City: dark blue-green growth on UP campus, 2501, February 12, 1950 (PUH, PNH, FC).

Genus CYLINDROSPERMUM Kutzing, 1843

Plants generally growing with other algæ, seldom in pure masses; trichomes in limited sheaths, long or short, flexuous with conspicuous basal portions tapering gradually towards hairlike apices; heterocysts and akinetes basal.

Key to the species of Cylindrospermum

1. Spores seriate .... *C. catenatum*
1. Spores solitary 2
  2. Spores cylindrical, up to 40μ long .... *C. stagnale*
  2. Spores oblong or ventricose-elliptic, generally shorter 3
3. Spore wall rough, punctate .... *C. majus*
3. Spore wall smooth 4
  4. Mature spore reddish, 20 to 30μ long and 12 to 14 μ wide. *C. licheniforme*
  4. Mature spore yellowish, 18 to 20 μ long and 9 to 12 μ wide. *C. muscicola*

CYLINDROSPERMUM CATENATUM Ralfs. Plate 9, fig. 114.

C. catenatum RALFS in Ann. Mag. Nat. Hist. 5 (1350) 338, pl. 7, fig. 14.

Plant mass mucoid, arranged semicircularly, indefinitely expanded; trichomes 4 μ wide, constricted at cell joints, with long cells, pale blue-green; spores oblong, blue-green when young becoming yellow and smooth on maturity, (13 to 18) ±17 μ long and (7–10) ±8.5 μ wide, (2–) 5 to 6 (–8) in catenate series; heterocysts oblong, (6–7 ±6.4 μ long and (–4) ±4.7 μ wide.

Single specimen examined.—LUZON: Manila: dark blue-green to almost black growth on moist sidewalk near fire hydrant, A. Flores street, Ermita, JDS, 616, January 22, 1950 (PUH, PNH, FC).

CYLINDROSPERMUM STAGNALE Bornet and Flahault. **Plate 9, fig. 115.**

C. stagnale BORNET and FLAHAULT in Ann. Sci. Nat. Bot. Bot. VII 7 (1888) 250.

Plant mass expanded, blue-green, floating or attached to other algæ or substrata; trichomes (3.8 to 4.5) generally 4 μ wide, slightly constricted at cell joints; heterocysts oblong, 6.5 μ wide; spores cylindrical, (32–) 28 to 32 (–40) μ long and (10–) 12 to 14 (–16) μ wide, wall smooth, yellow to brown, contents blue-green.

Single specimen examined.—LUZON: Manila: olivaceous blue-green growth floating on standing water in concrete bowl or old fountain in front of Malate Church, 424, October 17, 1949 (PUH, PNH, FC, NY).

CYLINDROSPERMUM MAJUS Kutzing. **Plate 9, figs. 116 and 116a.**

C. majus KÜTZING, Phycolog. Gen. (1843) 212.

Plant mass widely expanded, bright blue-green; trichomes flexuous, loosely entangled, 4 to 5 μ wide, constricted at joints; cells cylindrical, 5 to 6 μ long; heterocysts (10) 6 to 8 μ long, somewhat wider than vegetative cells; spores of different maturity sometimes up to 40 μ long and 10 to 15 μ wide, bright blue-green when young, ventricose-elliptic, red and roughened on maturity.

Specimens examined.—LUZON: Batangas: blue-green growth along the moist flat of Balete River, Lipa, 366, January 21, 1940 (PUH, FC); Bulacan: blue-green growth abundant on moist soil near artesian well, Calumpit, 412a, February 4, 1940 (PUH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: blue-green growth on saturated path near a fresh-water stream at Big Balatero, 943, April 22, 1941 (PUH, PNH, FC); rich blue-green growth in Aguada, 1845, April 2, 1949 (PUH, PNH, FC, NY, UC). PALAWAN: blue-green growth in Cuyo, 2851, June 9, 1951 (PUH, PNH, FC).

CYLINDROSPERMUM LICHENIFORME Kutzing. **Plate 9, figs. 117 and 117a.**

C. licheniforme KÜTZING in Bot. Zeit. (1847) 197.

Plant mass mucoid, forming indefinitely expanded spheroidal colonies; trichomes bright blue-green, slightly constricted, 4.2 μ wide; spores elliptic, becoming ventricose-elliptic, (20–) 20.4 to 26 (–30) μ long, 12 to 13 (–14) μ wide, smooth-walled, brownish-red; heterocysts oblong, 7 to 12 μ long, 5 to 6 μ wide.

Specimen examined. — LUZON: Batangas: blue-green abundant growth with *C. stagnale* along the moist flat of Balete River, Lipa, 371, January 21, 1940 (PUH, PNH, FC). PANAY: Capiz: dark blue-green growth in Roxas City, JDS, 1509, November 30, 1952 (PUH, PNH, FC). LUZON: Ilocos Norte: dark blue-green on moist bank near spring, north of Banna, 2234, June 5, 1950 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: blue-green growth on path near fresh-water stream at Big Balatero, 943a, April 22, 1941 (PUH, PNH, FC); rich blue-green purplish-tinted growth floating among grasses in Aguada, 1844, April 21, 1949 (PUH, PNH, FC). LUZON: Pampanga: deep blue-green growth on very moist flat at Nursery, 128, November 19, 1939 (PUH, PNH, FC). PALAWAN: bright blue-green growth in Araceli, 2927, June 15, 1951 (PUH, PNH, FC); rich blue-green growth in Babuyan, 2904, June 19, 1951 (PUH, PNH, FC). LUZON: Rizal: blue-green growth on moist soil near the vicinity of Hinulugang Taktak, Antipolo, 3756, February 20, 1956 (PUH, PNH, FC); Pasay City: blue-green growth among burned grasses, 3781, March 9, 1956 (PUH, PNH, FC).

CYLINDROSPERMUM MUSCICOLA Kutzing. Plate 9, fig. 118.

C. muscicola KÜTZING, Phycolog. German. (1845) 173.

Plant mass blackish blue-green, expanded; trichomes generally 3 to 4.2 (–4.7) μ wide, slightly constricted at cell joints; heterocysts oblong, 5 to 7 μ long, 4 μ wide; spores (10–) 14 to 18 (–20) μ long, (9–) 10 to 11 (–12) μ wide, oval, with brownish smooth wall, cell contents pale blue-green.

Specimens examined.—LUZON: Batangas: blue-green mass on muddy flat of Balete River, Lipa, 598, January 12, 1941 (PUH, PNH, FC); Ilocos Norte: dark blue-green plant mass floating on Cabalayangan Creek, Nueva Era, 3634, April 15, 1955 (PUH, PNH, FC); Laguna: deep blue-green growth in Los Baños, 2460, August 8, 1948 (PUH, PNH, FC); Pampanga: blackish blue-green growth on wet flat near Nursery, Arayat, 126, November 19, 1939 (PUH, PNH, FC); Rizal: deep blue-green mass with decaying *Spirogyra* sp. at Hinulugang Taktak, Antipolo, 663, January 25, 1941 (PUH, PNH, FC); Manila: greenish growth with *C. stagnale* on moist soil along Pennsylvania street, 102, November 18, 1939 (PUH, PNH, FC); blue-green growth on sidewalk at Vito Cruz Subdivision, 552, August 24, 1940 (PUH, PNH, FC).

Genus AULOSIRA Kirchner, 1878

Filaments solitary, scattered or in small fascicles; sheaths thin, colored at the ends; trichomes generally of the same diameter throughout, cells rectangular or barrel-shaped; heterocysts intercalary; akinetes single or in catenate series, sometimes adjacent to the heterocysts.

AULOSIRA IMPLEXA Bornet and Flahault. **Plate 9, fig. 119.**

A. implexa BORNET and FLAHAULT in Bull. Soc. Bot. France 32 (1885) 121, pl. 4, fig. 4.

Filaments brilliant blue-green, long and fasciculate, flexuous, enclosed in very firm thin sheaths; trichomes pale blue-green, (8–), 6.8 to 8.5 (–9) μ wide, cells distinctly rectangular, constricted at joints, cylindrical; heterocysts quadrate, similar to vegetative cells; spores several to many in a series.

Specimens examined.—LUZON: Bataan: dark blue-green growth in Tuyo, 2421, July 14, 1950 (PUH, PNH, FC, NY). PANAY: Iloilo: light and dark blue-green plant masses floating on irrigated rice paddies in Bo. Salvacion, Buenavista, JDS, 1094, August 20, 1952 (PUH, PNH, FC). LEYTE: olive-green, continuous, tough mat partly resting on sandy bottom and partly floating on surface of shallow pool about 75 ft. back of beach of airstrip in San Pablo Bay near Tacloban, *M. E. Britton 86*, July 4, 1945 (PUH, PNH, FC); olive-green stratum on soil at edge of swamp at Dulag, *M. E. Britton 114*, August 1, 1945 (PUH, PNH, FC). LUZON: Manila: bright blue-green plant mass floating on fishpond at *Bur. Sci. 109*, November 18, 1939 (PUH, PNH, FC).

Genus HORMOTHAMNION Grunow, 1867

Filaments usually growing parallel, a few developing into erect, somewhat ragged, expanded layers; sheaths thin, colorless; trichomes chainlike, usually several within the sheath; heterocysts intercalary; akinetes unknown.

Key to the species of Hormothamnion

Filaments generally branching and in tufts, 9.5 to 11.9 μ wide. *H. enteromorphoides*

Filaments generally entangled, 13.6 to 15.3 μ wide .... *H. solutum*

HORMOTHAMNION ENTEROMORPHOIDES Grunow. **Plate 10, fig. 120.**

H. enteromorphoides GRUNOW, Reise Ost. Freg. Nov., Algen. (1870) 31, pl. 1, figs. 25a–b.

Plant mucoid, confluent and agglutinated, greenish, bright blue-green, slightly entangled, parallel, somewhat flexuous, prostrate at base, with the branches usually briefly tapering towards the apices; filaments (7–) 9.5 to 11.9 (–9) μ wide, within mucoid, transparent sheaths; trichomes 6 to 10 (–7) μ wide, cells spherical-depressed, barrel-shaped, deeply constricted at the joints; heterocysts globose to somewhat cylindrical, 7 to 10 μ long and 6 to 7 μ wide; no spores seen.

Specimens examined.—MINDORO: Oriental Mindoro: in Puerto Galera: bluish-green growth on stream pool at Small Tabinay, 933, April 7, 1941 (PUH, PNH, FC); dark greenish-blue growth with sterile *Anabæna* and *P. Setchellianum* attached to old leaves of submerged *Vallisneria* at Sabang Cove, 1045, April 29, 1941 (PUH, PNH, FC); yellowish blue-green growth in Mahabang Parang, 1745, May 5, 1959 (PUH, PNH, FC, NY, UC); pale blue-green growth in Farola Point, 1932, April 26, 1949 (PUH, PNH, FC, NY, UC).

HORMOTHAMNION SOLUTUM Bornet and Grunow. Plate 10, figs. 121 and 121a.

H. solutum BORNET and GRUNOW in Ann. Sci. Bot. 7 (1888) 259.

Plant floccose much entangled, green or bright blue-green, mucoid; filaments (12–) 13.6 to 15.3 (–15) μ wide, straight; sheaths membranaceous, firm, hyaline; trichomes tortuous, much constricted at joints, (9–) 9.5 to 13.6 (–12) μ wide, cells discoideous, much depressed, barrel-shaped; heterocysts subquadrate.

Specimens examined.—PALAWAN: blue-green growth in Araceli, 2938, June 15, 1951 (PUH, PNH, FC, NY); blue-green growth on sand flats exposed during low tide at Taytay, *E. D. Merrill 9158*, April 19, 1913 PUH, PNH, FC).

Family RIVULARIACEÆ

Filaments may be solitary or forming aggregates as spherical and hemispherical masses, exhibiting basal-distal differentiation by pronounced tapering from base to apex; trichomes occur singly or in greater number within firm sheaths especially at the basal portion; heterocysts are usually basal, may be absent in some species; when heterocysts are intercalary, false branches may arise immediately below; hormogones are present; akinetes may be present or absent.

Key to the genera of Rivulariaceæ

1. Heterocysts absent .... *Amphithrix*
1. Heterocysts present 2

2. Filaments solitary, up to several in the sheath forming a somewhat aggregated mass 3
2. Filaments aggregated into crustaceous, gelatinous globular or somewhat globular masses 4
3. Filaments solitary, exhibiting simple false branches; trichomes usually single within the sheath .... *Calothrix*
3. Filaments generally dichotomously branching, trichomes several within the sheath .... *Dichothrix*
4. Filaments parallel, crustaceous .... *Isactis*
4. Filaments entangled, developing usually into a globular or somewhat globular colony 5
5. Branches numerous, remaining within the original sheath, or irregular 6
5. Branches numerous, developing centripetally into zones .... *Rivularia*
6. Branches densely crowded, forming fascicles ...... *Gardnerula*
6. Branches irregular within a globose irregular colony. *Brachytrichia*

Genus AMPHITHRIX Kutzing, 1843

Plant densely arranged below, developing above as erect, parallel and gently tapering filaments; sheaths thin; heterocysts and akinetes absent; reproduction by vegetative multiplication and hormogone formation.

AMPHITHRIX JANTHINA Bornet and Flahault. Plate 10, fig. 122.

A. janthina BORNET and FLAHAULT, Ann. Sci. Nat. Bot. VII 3 (1886) 344.

Plant mass crustaceous, thin, purple; filaments long, in very thin sheaths, 1.5 to 2.2 μ wide; trichomes pale blue-green, gradually tapering, slightly constricted at cell joints; cells of unequal length, protoplasmic contents homogeneous.

Single specimen examined.—LUZON: Abulug: pale blue-green growth on bark, *Robert A. Copeland, Jr. 12a,* July 14, 1945 (PUH, PNH, FC, NY).

Genus CALOTHRIX Agardh, 1824

Filaments forming penicillate tufts or widely expanded velvety layers; false branching quite common and occurring midway the filament; trichomes tapering from basal heterocysts, equal in diameter and tapering only towards their apices, within firm, sometimes lamellose sheaths, some with intercalary heterocysts; cells short at the basal portion becoming longer towards the apices.

Key to the species of Calothrix

1. Attenuation of trichomes from basal to terminal portions not obvious. *C. pilosa*

1. Attenuation of trichomes from basal to terminal portions obvious. .. 2
    2. Filaments branched, heterocrysts basal and intercalary. *C. parietina*
    2. Filaments unbranched, heterocysts basal only .... *C. confervicola*

CALOTHRIX PILOSA Harvey. Plate 10, figs. 123 and 123a.

C. pilosa HARVEY, Ner. Bor. Amer. Part 3 (1858) 106, pl. 480, figs. 1–3.

Plant mass widely expanded, caespitose, dark blue-green; filaments decumbent with very thick rigid striated sheaths, (10–) 7.2 to 30 (–40) μ wide, dark yellow, oftentimes roughened with age; trichomes generally (10–) 5.9 to 17.0 (–20) μ wide, many in hormogonial forms, interrupted with heterocysts, tapering gradually towards apex; cell contents from light yellow to dark blue-green.

Specimens examined.—LEYTE: dark blue-green growth on rocks along the beach just above the high tide level, Biliran, *R. C. McGregor 4767,* June 20, 1914 (PUH, PNH). MINDORO: Oriental Mindoro: in Puerto Galera: yellowish-green to bright blue-green growth above the tide mark at Ensenada Cove, 1929, June 1, 1946 (PUH, PNH, FC, NY, UC).

CALOTHRIX PARIETINA Thuret. Plate 10, fig. 124.

C. parientina THURET, Ann. Sci. Nat. Bot. ser. 1 6^{e} (1875) 381.

Filaments attached on stones with other algæ, (10–) 7 to 12 μ wide, usually crustaceous, chartaceous dark yellow blue-green, bulbous and bearing heterocyst at the base; heterocysts usually basal, rarely intercalary; trichomes 5 to 10 μ wide, olive to blue-green, with short cells; some are epiphytic on *Anacystis montana.*

Specimens examined.—PANAY: Iloilo: blackish growth on damp corner of the well of the Catholic church in Jaro, *JDS 1057,* July 6, 1952 (PUH, PNH, FC). PALAWAN: dark greenish-blue to yellowish blue-green growth with *Schizothrix lardacea* Gom. in Iwahig Penal Colony, 2869, June 18, 1951 (PUH, PNH, FC, NY).

CALOTHRIX CONFERVICOLA Agardh. Plate 10, fig. 125.

C. confervicola AGARDH, Syst. Alg. (1824) 20.

Plants usually attached as epiphytes on many marine red algæ, gregarious, dirty and easily deformed, blackish-green; trichomes irregular, pale blue-green within colorless, usually transparent sheaths, (10–) 8.7 to 14.4 (–18) μ wide, tapering gradually towards the apices; heterocysts present, hormogones numerous.

More materials are needed in order to have a more definite knowledge of the species.

Single specimen examined.—BABUYAN ISLANDS: pale yellowish-green growth on coral limestone near shore, Calayan Island, *R. C. McGregor 23*, September 30, 1903 (PUH, FC).

Genus DICOTHRIX Zanardini, 1858

Filaments penicillate, dichotomously branched; trichomes several within the conspicuous sheath; heterocysts basal or intercalary.

DICOTHRIX ORSINIANA Bornet and Flahault.

D. orsiniana BORNET and FLAHAULT, Ann. Sci. Bot. VII 3 (1886) 376.

Plant mass cæspitose, fasciculate or penicillate, bright yellowish blue-green; filaments flexuous, 10 to 12 μ wide, with adpressed false branches and basal heterocysts; trichomes generally (6–7.5) 8.5 μ wide, enclosed in moderately thick and yellow sheaths, very gradually attenuate into hairlike ends.

Genus ISACTIS Thuret, 1875

Filaments crustaceous, parallel and erect; branches generally wanting; heterocysts basal, akinetes unknown.

ISACTIS PLANA Thuret. Plate 10, fig. 126.

I. plana THURET, Ann. Sci. Nat. Bot. ser. 6e 1 (1875) 382.

Plant mass abundant, dark blue-green, frequently exposed on rocks along the shore at low tide; filaments crowded, enclosed in a sheath, somewhat corrugated; trichomes (7–) 6.5 to 7.7 (–9) μ wide, irregular, generally parallel, tapering towards the apices; heterocysts globular and greatly enlarged; cells generally short.

Single specimen examined.—MINDORO: Oriental Mindoro: yellowish dark blue-green growth in East Muelle and San Isidro, Puerto Galera, 1106, May 26 and 28, 1946 (PUH, PNH, FC, NY).

Genus RIVULARIA Agardh, 1824

Plant forming usually very firm and tough mucilaginous globose mass, solid, later becoming hollow colonies; filaments radiating from the center, repeatedly branched, the branches forming distinct zonations, tapering from basal heterocysts into hairlike points; heterocysts basal; akinetes not in all species.

RIVULARIA BULLATA Berkeley. Plate 10, fig. 127.

R. bullata BERKELEY, Glean. Brit. Alga. (1833) 8, pl. 2, f. 1, habit, part of colony and filaments highly magnified.

Plant mass vesiculous lobate, up to (6) 4.8 cm in diameter, expanded, hollow, blue-green; filaments compact; trichomes (5–) 3.4 to 6.8 (–8) μ wide, blue-green, moderately constricted at cell joints, enclosed in yellowish hyaline sheaths; heterocysts globular.

Single specimen examined.—PALAWAN: yellowish dark blue-green growth on rocks exposed at low tide, *E. D. Merrill 9117*, April 19, 1913 (PUH, PNH, FC, UC).

Genus GARDNERULA J. De Toni, 1936

Plant mass up to 4 cm high, consisting of subdichotomously branching fascicles; numerous filaments enclosed in a common sheath; trichomes tapering towards their apices; heterocysts basal and intercalary.

GARDNERULA CORYMBOSA (Harvey) J. de Toni. Plate 10, figs. 128, 128a, and 128b.

G. corymbosa (Harvey) J. DE TONI, Osterr. Bot. Zeit. Ir. Fried. (1936) 337, fig. 1.

Plant mass dark blue-green to yellowish blue-green, widely expanded into hairy crowded, much subdichotomously branched fascicles; filaments not very long, nearly straight, enclosed in a transparent sheath, sometimes yellowish in matured specimens; trichomes 5 to 6 μ wide, gradually tapering into coarse hairs for some distance at their apices; cell joints constricted and not constricted; hormogones numerous; heterocysts conspicuous and usually apart, basal and intercalary, subspherical, cylindric to quadrate.

Single specimen examined. — MINDORO: Oriental Mindoro: blue-green felty growth on rocks or fine sandy bottom exposed along shores in ordinary tide, 1931, May 19, 1949 (PUH, PNH, FC).

Genus BRACHYTRICHIA Zanardini, 1872

Colonies at first solid, finally becoming hollow and torn, usually attached to rocks; filaments embedded in very firm gelatinous sheath, irregularly disposed, much curved, parallel and drawn above into hairs at apices, branches irregular; heterocysts intercalary without any order.

Key to the species of Brachytrichia

1. Plants cartilaginous, macroscopic, trichomes mostly Y-shaped branches. .... *B. Quoyi*

1. Plants cartilaginous, microscopic, trichomes irregularly branched.
B. maculans

BRACHYTRICHIA QUOYI Bornet and Flahault. **Plate 11, fig. 129.**

B. quoyi BORNET and FLAHAULT, Ann. Sci. Bot. VII **4** (1886) 373.

Plant mass consisting of small to large gizzardlike irregular balls, much inflated up to (5) 7 cm in diameter, widely expanded, usually very dark to brilliant blue-green; trichomes irregularly disposed V to Y-shaped branching often tapering into whiplike apices; interrupted with intercalary or somewhat exerted heterocysts.

Specimens examined.—MINDORO: Oriental Mindoro: all in Puerto Galera: brownish dark-green growth on rocks exposed during low tide, Puerto Galera Bay, *H. H. Bartlett 13777*, May 12 to 17, 1935 (PUH, PNH, FC); dark blue-green abundant growths attached to rocks in Honduras Bay, 1024, May 23, 1946 (PUH, PNH, FC, NY); dark blue-green to dark green growths in Honduras Bay and West Muelle, 1089, May 27, 1946 (PUH, PNH, FC, NY); dark blue-green growths on rocks always exposed during low tide at Varadero Point, Honduras Bay, 814, April 8, 1941 (PUH, PNH, FC, NY); very dark blue-green growth in Dooñgan Cove, 1672, May 4, 1948 (PUH, PNH); olivaceous-green growth in Big Balatero Stream, 1697, May 14, 1948 (PUH, PNH, FC, NY); dark blue-green growth in Small Tabinay 1876, May 4, 1949 (PUH, PNH, FC, NY). PALAWAN: yellowish-green growth in Catadman Sound, Cuyo, 3020, June 6, 1951 (PUH, PNH, FC).

BRACHYTRICHIA MACULANS Gomont.

B. maculans GOMONT, Bot. Tidskr. **24** (1901) 210, pl. 5, fig. 5–7.

Plants very small and dark blue-green; filaments irregular, tapering, with basal and intercalary heterocysts and conspicuous sheaths; trichomes 6 to 7.7 μ wide.

Single specimen examined.—MINDORO: Oriental Mindoro: dark blue-green growth on rocks exposed during low tide in an open sea at San Isidro, 1076, April 22, 1941 (PUH).

Family SCYTONEMATACEÆ

Filaments generally developing false branches usually at heterocysts or remote from heterocysts; trichomes uniseriate, enclosed in usually very firm, generally lamellated sheaths of varying color and development; cells short, barrel-shaped, quadrate, and at times constricted in some specimens; akinetes seldom observed, hence, had not been utilized in taxonomical study.

Key to the genera of Scytonemataceæ

1. Heterocysts absent .... *Plectonema*
1. Heterocysts present 2
    2. Mostly terrestrial, sheaths generally thick and conspicuous, false branching solitary and in pairs .... *Scytonema*
    2. Mostly aquatic, sheaths generally thin, false branching solitary. *Tolypothrix*

Genus PLECTONEMA Thuret, 1875

Filaments solitary or growing with other algæ, at times developing into woolly expanded mats; false branches single or in pairs; trichomes usually very long, within firm sheaths, generally constricted at cell joints, straight, seldom tapering; heterocysts common.

Key to the species of Plectonema

1. Plants large, trichomes 3 μ or more wide 2
1. Plants small; trichomes less than 3 μ wide 3
    2. Growth indefinite; filaments coarse and ragged; trichomes not torulose, 28 to 47 μ wide .... *P. Wollei*
    2. Growth somewhat limited; filaments slender and smooth, trichomes torulose, 7 μ wide .... *P. purpureum*
3. Filaments generally flexuous, densely entangled; trichomes usually lightly pinkish; cell joints not constricted .... *P. roseolum*
3. Filaments generally somewhat straight, loosely entangled; trichomes yellowish to dark blue-green; cell joints markedly constricted. *P. Nostocorum*

PLECTONEMA WOLLEI Farlow. Plate 11, fig. 130.

P. Wollei FARLOW, Bull. Bussey Inst. 77 (1875) (en note).

Filaments usually floating, bundled, rough, blue-green; trichomes very coarse, densely entangled and substraight, forming hormogones inside very ragged thick sheaths, constricted at cell joints; protoplasm granular, purplish or yellow, blue-green, sometimes lead-colored; apical cell rotund.

Specimens examined—CEBU: violet dark blue-green growth in fresh-water lake in mountains near Toledo, *R. C. McGregor 70*, November 1906 (PUH, PNH, FC). LUZON: Laguna: blackish deep blue-green growth with *Chamæsiphon minutans* and *L. æstuarri* submerged in water of swimming pool as abundant growth on stones, Pansol, Calamba, 464, February 25, 1940 (PUH, PNH, FC); in Los Baños: blackish deep blue-green growth attached to rocks, *E. Quisumbing 77296*, October 13, 1929 (PUH, PNH); blackish blue-green growth in irrigation ditches, *E. Quisumbing 77298,* October 13, 1929 (PUH, PNH); blackish growth in irrigation ditches, *E. Quisumbing 77321,* October 12, 1929 (PUH, PNH, FC). LUZON: Quezon City: blackish deep blue-green growth with *Oocystis* sp. in Kamuning, 2542, August 19, 1950 (PUH, PNH, FC).

PLECTONEMA PURPUREUM Gomont. Plate 11, fig. 131.

P. purpureum GOMONT, Monogr. Oscill. (1893) 101, pl. 1, f. 8, 9.

Plant mass dark purplish to blue-green; trichomes flexuous and densely entangled, enclosed in sheaths, pale blue-green, deeply constricted at cell joints, tapering, false branches evident; apical cell rotund; protoplasm homogeneous.

Specimens examined. — PANAY: Capiz: dark blue-green growth on damp soil beside Municipal Building in Ivisan, *JDS 1512,* November 30, 1952 (PUH, PNH, FC). LUZON: Laguna: blackish colonial growth attached to stones at Students' Quarters, Forestry Camp, Los Baños, 380, January 28, 1940 (PUH, FC); Manila: blue-green growth in filter of drinking water at UP Department of Botany, 708, no date, (PUH, FC).

PLECTONEMA ROSEOLUM Gomont.

P. roseolum GOMONT, Monogr. Oscill. (1893) 102, pl. 1, fig. 9, 10.

Plant mass agglutinated, light rose-colored, chartaceous when dry; trichomes very irregularly entangled, 1.2 to 1.8 μ wide, blue-green, some purplish-red, not constricted at cell joints; and cell rotund, protoplasm finely granulated.

PLECTONEMA NOSTOCORUM Bornet and Thuret. Plate 11, fig. 132.

P. Nostocorum BORNET and THURET, Notes Algolog. 2 (1880) 137.

Plant mass usually growing with other algæ, chartaceous, dark blue-green; trichomes very narrow, 1.0 to 1.5 μ wide, within thin agglutinated sheaths, suberect, flexuous, deeply constricted at cell joints, end cell rotund; protoplasm finely granular, sometimes homogeneous.

Specimens examined.—LUZON: Nueva Vizcaya: yellowish-green growth in trough which carries salt water from salt spring to Canas, vicinity of Dupax, *R. C. McGregor 2901,* March, 1912 (PUH, PNH). MINDORO: Oriental Mindoro: dark blue-green growth in Puerto. Galera, 1758, April 19, 1948 (PUH, PNH, FC). LUZON: Pampanga: yellowish blue-green growth with *Lyngbya* sp. and *Phormidium tenue* submerged in water coming from an artesian well at Nursery, Arayat, 133, November 10, 1939 (PUH, PNH, FC); Rizal: very mucilaginous blue-greenish growth floating on or submerged in pond at Mandaluyong, 161, December 10, 1939 (PUH, FC); blackish blue-green growth on moist base on artesian well at Bo. Mangahan, Marikina, JDS, 938, May 18, 1952 (PUH, PNH, FC); yellowish blue-green growth with *C. parietina* and *C. epiphytica* under flowing water at fountain in Rotonda leading to San Juan, 500, May 12, 1940 (PUH, PNH, FC); Manila: dull blue-green growth in Geliños, Sampaloc, 2440, July 24, 1950 (PUH, PNH, FC).

Genus SCYTONEMA Agardh, 1824

Filaments in many species forming woolly expanded mats; false branches arising singly or in pairs from the heterocysts or between heterocysts by lateral perforations at regions of dead vegetative cells; filaments solitary, sometimes constricted, within firm, generally thick, much expanded sheaths, variously colored in some species; cells short, quadrate or cylindrical; heterocysts short or quadrangular-globose; akinetes rare.

Key to the species of Scytonema

1. Sheaths homogeneous, of parallel layers, usually membranaceous and hyaline 2
1. Sheaths lamellose, developing wings or diverging layers, usually bright colored 8
    2. Aquatic, attached or floating 3
    2. Terrestrial, on rocks or trees 5
3. Filaments 8.2 to 18.7 μ wide .... *S. tolypothrichoides*
3. Filaments wider 4
    4. Filaments 15.9 to 20.4 μ wide .... *S. coactile*
    4. Filaments 23.8 to 28.9 μ wide .... *S. cincinnatum*
5. Sheaths thick, gelatinous .... *S. stuposum*
5. Sheaths thinner, membranaceous or hyaline 6
    6. Sheaths conspicuously lamellose .... *S. guyanense*
    6. Sheaths not lamellose 7
7. Filaments 6.8 to 13.6 μ wide .... *S. Hofmannii*
7. Filaments 13.6 to 18.7 μ wide .... *S. ocellatum*
    8. Lamellation wide, developing into winglike expansion. *S. alatum*
    8. Lamellation dilated, otherwise developing diverging layers .. 9
9. Filaments 28.9 to 57.8 μ wide .... *S. crassum*
9. Filaments narrower 10
    10. Filaments 15.3 to 18.7 μ wide, sheaths variously colored. *S. mirabile*
    10. Filaments 16 to 27.2 μ wide, sheaths generally yellowish. *S. Myochrous*

SCYTONEMA TOLYPOTHRICOIDES Kutzing **Plate 11, figs. 133 and 133a.**

S. tolypothricoides KÜTZING, Sp. Alg. (1849) 307.

Plant mass cæspitose, usually floating on water; filaments (10–) 8.2 to 18.7 (–15) μ wide, purple to bright blue-green, with long and flexuous false branching; trichomes 8 to 14 (–12) μ wide, within hyaline, sometimes lamellose sheaths; cells subquadrate to very long, with blue-green to yellowish blue-green, densely granular protoplasm; heterocysts subquadrate to very long.

Specimens examined—LUZON: Ilocos Norte: light yellowish-green to dark blue-green growth floating extensively in Paoay Lake, 2256, June 8, 1950 (PUH. PNH, FC). Quezon City: light to dark greenish-blue growth in Balara, 2503, February 26, 1950 (PUH, PNH, FC, NY); dark greenish-blue to yellowish-brown growth in Kamuning, 2536, August 19, 1950 (PUH, PNH, FC); greenish-blue to black growth on cemented walls of aquarium, La Mesa Park, Novaliches, 3725, January 27, 1956 (PUH, PNH, FC).

SCYTONEMA COACTILE Montagne. Plate 11, figs. 134 and 134a

S. coactile MONTAGNE in Kützing, Sp. Alg. (1849) 305.

Plant mass silky, dark to light blue-green; filaments flexuous, (18–) 15.9 to 20.4 (–24) μ wide; trichomes twisted, (12–) 13.6 to 18 μ wide, some separating from firm, hyaline and membranaceous sheaths, cells and heterocysts generally quadrate, the latter, rare.

Specimens examined.—LEYTE: Near San Joaquin: pale blue-green to brownish-green thick clumps of filamentous growth completely covering the surface of a small pond, *M. E. Britton 148*, October 7, 1945 (PUH); small pale green to brownish-green clumps of filamentous algæ completely covering the surface of a small pond, *M. E. Britton 150*, October 10, 1945 (PUH, PNH, FC). PALAWAN: in Iwahig Penal Colony: bright blue-green to greenish-brown growth, 2875, June 18, 1951 (PUH, PNH, FC, NY); yellowish blue-green to brownish growth, 2884, June 18, 1951 (PUH, PNH, FC); brownish blue-green growth, 2891, June 18, 1951 (PUH, PNH, FC); Quezon City: greenish-blue growth in Kamuning, 2533, August 19, 1950 (PUH, PNH).

SCYTONEMA CINCINNATUM Thuret. Plate 11, fig. 135.

S. cincinnatum THURET, Ann. Sci. Nat. Bot. ser. 6e 1 (1875) 380.

Plant mass thick, coarse, ragged; filaments (18–) 23.8 to 28.9 (–30) μ wide, blue-green, lynbyaceous; trichomes blue-green sometimes brown, (14–) 21 to 24.5 (–30) μ wide, within firm, hyaline sheaths impregnated with epiphytes; heterocysts differently colored, depressed-globose to quadrate.

Single specimen examined.—LUZON: Ilocos Norte: dark blue-green growth in shallow stream near Cabalayangan Creek, Nueva Era, 3635, April 15, 1956 (PUH, PNH, FC, NY).

SCYTONEMA STUPOSUM Bornet. Plate 11, fig. 136.

S. stuposum BORNET in Bornet et Thuret, Notes Algolog. 2 (1880) 146.

Plant mass cushion-shaped and much expanded, deep violet to dark red; filaments stout, (16–) 18.7 to 25.5 (–30) μ wide, with solitary or paired branches; trichomes bright violet, olive to blue-green, (12–) 15.3 to 20.4 (–18) μ wide, within thick gelatinous sheaths that become thinner towards the apex; cells quadrate or shorter than broad, subquadrate, heterocysts globose or quadrate.

Specimens examined.—LUZON: Bataan: blue-green growth on *Neckeropsis scroibiculata* (Nees) Fl. on rocks, Lamao River, *R. S. Williams 849a*, November, 1903 (PUH); Ilocos Norte: in Banna: bright blue-green to black growth on sides of swimming pool under water level, 2226, June 5, 1950 (PUH, PNH, FC); dark blue-green to dark greenish-brown growth on sides of swimming pool above water level, 2227, June 5, 1950 (PUH, PNH, FC); Laguna: very dark blue-green growth on moist canal at Students' Mess Hall, Forestry Camp, Los Baños, 382, January 28, 1940 (PUH, FC). LEYTE: greenish-black growth on rocks in small stream, Biluan, *R. C. McGregor 4768*, June 20, 1914 (PUH, PNH). MINDORO: Oriental Mindoro: in Puerto Galera: growing on rocks near source of water supply, 726, April 2, 1941 (PUH, PNH, FC); dark brownish-black growth on trunk of coconut palm at Small Tabinay, 1116a, May 7, 1941 (PUH, PNH. LUZON: Rizal: bluish to greenish-black growth in vicinity of western boundary of Marikina watershed reservation, 3 miles east of Montalban, *H. H. Bartlett, 14679*, July 4, 1935 (PUH, PNH); growing on bark of tall Santol tree (*Sandoricum kœtjape*) in Bo. Santolan, Marikina, 906, May 12, 1952 (PUH, PNH, FC, NY).

SCYTONEMA GUYANENSE Bornet and Flahault. Plate 12, figs. 137 and 137a.

S. guyanense BORNET and FLAHAULT, Ann. Sci. Nat. Bot. VII 3 (1887) 94.

Plant mass thick, felty, pulvinate, widely expanded, dark blue-green; filaments 15 to 30 (–21) μ wide, false branching long and flexuously aggregated; trichomes (10–) 8.5 to 15.3

(–16) μ wide, variously colored, within firm, usually ochraceous and strongly lamellated sheaths; cells generally quadrate; heterocysts mostly rectangular, globose, depressed in some specimens.

Specimens examined.—LUZON: Ilocos Norte: in Banna: blackish dull blue-green growth on moist side of road km. 573, 2232, June 5, 1950 (PUH, PNH, FC); dull dark olivaceous bluish-green growth on moist rocks near waterfalls, 2237, June 5, 1950 (PUH, PNH, FC, NY); dark greenish black growth on moist rocks beside Banna waterfalls, 2241, June 11, 1950 (PUH, PNH, FC, NY); dark brown feltlike growth on shaded road bank, Baay, Batac, 2259, June 8, 1950 (PUH, PNH, FC, NY); subærial thin feltlike brown to black growth on the cemented slope of the bridge, 3622, April 11, 1955 (PUH, PNH, FC); in Laoag: dark blue-green to brownish-black feltlike growth on the brick walls of church, 2246, June 6, 1950 (PUH, PNH, FC, NY); thick brown to blackish brown plant mass growing on the brick walls of the Roman Catholic Church, 3603, April 10, 1955 (PUH, PNH, FC). PANAY: Iloilo: blue-green to dark purplish-brown growth on very high cliffs above Salag, Buenavista, Guimaras Island, 1119, November 23, 1952 (PUH, PNH, FC, NY); light yellow-green growth on rocks in Ulian (Alunonan) River, alt. 475 mm, *C. B. Robinson 18256*, January 9, 1913 (PUH, PNH). LUZON: Laguna: yellowish-brown to dark brown growth on big pot of Calamba park, Calamba, 3717, December 28, 1955 (PUH, PNH, FC); dark blue-green growth in Los Baños, *E. Quisumbing 77322*, October 1929 (PUH). LEYTE: thin paper-like, blue-green stratum on moist sandy soil at edge of pond, San Joaquin, *M. E. Britton 142*, October 7, 1945 (PUH, PNH, FC). LUZON: Mountain Province: in Baguio: blackish-green growth abundant on old bark of pines and on stones along the road at Jungle Place, 202, December 27, 1939 (PUH, PNH); blackish blue-green growth with *Trentepohlia* sp. on old bark of pines and on stones, 203, December 27, 1940 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: blackish blue-green feltlike growth abundant on calcareous rocks at Waterfall, Bisayaan, 1089, May 5, 1941 (PUH, PNH); blackish growth on trunk of coconut palm at Small Tabinay, 733, April 7, 1941 (PUH, PNH, FC); feltlike olivaceous-green growth on cliffs high above tide mark at West Muelle, 722, March 31, 1941 (PUH, PNH, FC). PALAWAN: in Cuyo:

blackish dark blue-green growth, 2831, June 12, 1951 (PUH, PNH, FC); brownish-green growth, 2841, June 9, 1951 (PUH, PNH, FC); black feltlike growth in Iwahig Penal Colony, 2882, June 18, 1951 (PUH, PNH, FC). LUZON: Rizal: bright greenish-yellow growth on embankment along the road, Antipolo, 661, January 25, 1941 (PUH, PNH, FC); greenish-brown feltlike growth on dry stone walls along the highway at Mandaluyong, 510, May 12, 1940 (PUH, PNH, FC); in Marikina: blackish-green, spongelike growth on roofs of rice mill, 416, February 2, 1940 (PUH, PNH, FC); dull, dark blue-green growth on moist soil of unplanted rice paddy at Bo. Mangahan, JDS, May 18, 1952 (PUH, PNH, FC, NY); dark yellowish-green growth on earthy banks of road, Montalban, *C. B. Robinson, 9551*, November 2, 1909 (PUH, PNH); blackish-green growth on root debris of a fern pot at Tanay, 435, February 9, 1940 (PUH, FC); Manila: yellowish-brown growth on stone walls of premises of Phil. Long. Dist. Tel. Co., Marques de Comillas, 584, January 8, 1941 (PUH, PNH, FC); thick blackish growth on cemented aisle of second floor of Meralco Bldg., San Marcelino street, 182, December 15, 1939 (PUH, PNH, FC); deep brownish-green, spongelike growth on stones of a street canal at Singalong Subdivision, January 3, 1940 (PUH, PNH); in UP: grayish deep blue-green growth on slightly moist lawn of Palma Hall, 91, November 19, 1931 (PUH, PNH, FC); dark grayish-green growth on shaded wall of cemented tank at the Botanical Garden, 592, January 11, 1941 (PUH, PNH, FC); Quezon City: in Balara: yellowish blue-green growth, 2487, March 24, 1949 (PUH, PNH, FC); blackish growth, 2548, August 26, 1950 (PUH, PNH, FC, NY, UC); greenish-black feltlike growth in Kamuning, 2491, January 29, 1949 (PUH, PNH, FC); thick velvety black growth on cement walls of the dam, La Mesa Park, Novaliches, 3738, February 5, 1956 (PUH, PNH, FC); deep grayish black growth with *S. javanicum* on a dry canal, 181, December 13, 1939 (PUH, PNH, FC); on UP campus: black growth, 2444, July 27, 1950 (PUH, PNH, FC); dark blue-green growth with sporeless *Cylindrospermum* sp., 2427, July 22, 1950 (PUH, PNH, FC, NY); olivaceous deep blue-green growth, 2518, February 28, 1950 (PUH, PNH, FC); black growth, 2523, February 28, 1950 (PUH, PNH, FC).

SCYTONEMA HOFMANNII Agardh. Plate 12, fig. 138.

S. Hofmannii AGARDH, Syn. Alg. Scand. (1817) 117.

Plant mass cushion-shaped, pulvinate and widely expanded, up to 3 mm in thickness, variously colored but generally black to blue-green; filaments (7–) 6.8 to 13.6 (–12) μ wide, in vertical united fascicles, false branching aggregate and short; trichomes (5–) 5.4 to 13.7 (–10) μ wide, generally blue-green, within firm, narrow and somewhat colored sheaths; cells rectangular, or unequal in length; heterocysts oblong to globose and depressed.

Specimens examined.—LUZON: Abra: blackish plant mass growing extensively on mountain side at Banat Park, Cordillera Mountains, 3642, April 17, 1955 (PUH, PNH, FC, NY); Agusan: greenish-blue growth with *C. stagnina f. rupestris* on damp rock in stream, west slope of Mt. Hilong-Hilong at an altitude of 650 ft., Butuan Subprovince, *C. M. Weber 1334*, March 13, 1911 (PUH); Bataan: blackish growth in Balanga, 2405, July 12, 1950 (PUH, PNH, FC); Batangas: in Lipa City: dark brown sometimes reddish growth with *H. byssoidea* and *S. javanicum* on dry bank of Balete River, 367, January 21, 1940 (PUH, PNH, FC); blackish and somewhat turfy growth on dried trunk of coconut tree at Balete, 369, January 21, 1940 (PUH, PNH, FC); Ilocos Norte: dark blue-green growth on moist soil among grasses near the bridge, Bacarra, 3620, April 11, 1955 (PUH, PNH, FC); luxuriant brown to brownish-black growth on the exterior brick walls of the parochial church, Bangui, 3657, April 23, 1955 (PUH, PNH, FC, NY); in Laoag: blackish blue-green growth on moist sides of water barrel near the Normal School, 3604, April 10, 1955 (PUH, PNH, FC, NY); brown feltlike growth at the sides of moist tank of Electric Plant, 3613, April 18, 1955 (PUH, PNH, FC, NY); dark blue-green to brownish-black growth on the sides of water tank of Electric Plant, 3613a, April 18, 1955 (PUH, PNH, FC); blackish growth on east wall of Paoay church, Paoay, 2268, June 10, 1950 (PUH, PNH, FC, NY); black growth on old brick pillar of church, Sarrat, 2248, June 7, 1950 (PUH, PNH, FC, NY); Laguna, in Los Baños: blue-green growth in irrigation ditches, 77303, October 13, 1929 (PUH, PNH); grayish-black growth, *E. Quisumbing 77312,* October, 1929 (PUH, PNH, FC); brownish blue-green growth along the road from School of Forestry Camp to creek, 388, January 28, 1940 (PUH, PNH, FC); brownish-green abundant growth with *H. byssoidea* and *S. guyanense* on cement wall of Library Bldg., School of Forestry, 389, January 28, 1940 (PUH, PNH, FC); blue-green growth in vicinity of the hot spring at Talakay, 2466, August 14, 1948 (PUH, PNH, FC) deep blue-green feltlike growth on stone walls of Sta. Romana residence near the hot springs, 3721, December 28, 1955 (PUH, PNH, FC); Mountain Province: in Baguio: growing with *Endotrichella elegans*, *R. S. Williams*, September 15, 1904 (PUH, PNH); blackish growth with *Glœocapsa alpicola* between Bangod and Lubuangan, *A. C. Herre*, May 6, 1923 (PUH, PNH, FC). MINDORO: olive-green growth on decaying logs submerged during high tide, 720, March 31, 1941 (PUH, PNH, FC); brownish blue-green growth in Muelle, 1710, April 20, 1948 (PUH, PNH, FC); dark blue-green growth with *H. byssoidea* and *S. ocellatum* on rocks under palm near the seashore at Medio Island, 972, April 11, 1941 (PUH, FC); blackish blue-green growth on boulders on exposed part of shallow stream at San Isidro, 953, April 23, 1941 (PUH, PNH, FC); blackish blue-green growth with *H. byssoides* and *S. ocellatum* on pieces of stones in campus of the Biological Station, 1078, May 2, 1941 (PUH, PNH, FC); light blue-green growth in Aguada, 1720, May 3, 1948 (PUH, PNH, FC); light blue-green growth with *H. byssoidea* and *S. ocellatum* along dry path of Dulañgan, 1087, May 5, 1941 (PUH, PNH); olivaceous-green growth along dry path of Balatero Hill, 1119, May 7, 1941 (PUH, PNH); blue-green growth along dry path of Balatero Hill, 1119, May 7, 1941 (PUH, PNH); blue-green growth on shaded path of Balatero Hill, 1118, May 7, 1941 (PUH, PNH); ash-colored growth with *S. figuratum* on cliffs above high tide, west part of Muelle (PUH). PALAWAN: in Araceli: dark brown growth, 2920, June 15, 1951 (PUH, PNH, FC); blackish growth with *G. alpicola* on bark of tree, 2922, June 15, 1951 (PUH, PNH, FC, NY); blue-green growth, 2930, June 15, 1951 (PUH, PNH, FC); blackish dark blue-green growth in Babuyan, 2905, June 19, 1951 (PUH, PNH, FC, NY); in Cuyo: brownish black growth, 2802, June 10, 1951 (PUH, PNH, FC, NY); black velvety growth, 2804, June 10, 1951 (PUH, PNH, FC); brownish-black growth, 2823, June 11, 1951 (PUH, PNH, FC, NY); black growth, 2840, June 9, 1951 (PUH, PNH, FC, NY); blackish rich blue-green velvety growth, 2846, June 9, 1951 (PUH, PNH, FC); in Puerto Princesa: dark blue-green growth, 2903, June 19, 1951 (PUH, PNH, FC, NY); blackish blue-green growth, 2912, June 20, 1951 (PUH, PNH, FC);

dark blue-green growth, 2912a, June 20, 1951 (PUH PNH, FC, NY); blackish growth on Acacia bark, 2912c, June 20, 1951 (PUH, PNH, FC, NY); black, thick growth at Inabuyan, 14 kms. north of the poblacion, June 20, 1951 (PUH, PNH, FC); in Tapun: blackish growth 2892 June 20, 1951 (PUH, PNH, FC, NY); deep blue-green growth, 2892b, June 20, 1951 (PUH, PNH, FC, NY); dark blue-green to black growth, 2894, June 20, 1951 (PUH, PNH, FC); dark blue-green growth, 2898, June 20, 1951 (PUH, PNH, FC, NY). LUZON: Pampanga: blue-green sometimes blackish growth with *S. muscorum* on drying flat at Nursery, Arayat, 523, May 22, 1940 (PUH, PNH, FC); Rizal: in Antipolo: forming black covering with *S. guyanense* on dried stone walls of Antipolo church, 487, May 1, 1940 (PUH, PNH, FC); black feltlike growth with *H. byssoidea* and *S. guyanense* on stones at the Luzon Bus Line Station, 664, January 25, 1941 (PUH, PNH, FC); yellowish blue-green growth on embankment along the roadside, 667, January 25, 1941 (PUH, PNH, FC); brownish black growth on loose rocks in front of Antipolo church, 3767, February 20, 1956 (PUH, PNH, FC); blackish growth on adobe stones lying in front of Antipolo church, 3768, February 20, 1956 (PUH, PNH); deep grayish-black growth on dried stones at Mandaluyong, 167 December 10, 1939 (PUH); in Marikina: dark bluish spongy growth on old stone wall of rice mill, 415,, February 2, 1940 (PUH, FC); blackish growth with *H. byssoidea* and *S. guyanense* on moist stone wall of church, 418, February 2, 1940 (PUH, FC); blackish growth on soil clinging to roots of higher plants, Montalban, 2750, February 11, 1956 (PUH, PNH, FC); black growth on bank of Montalban river, 3748, February 11, 1956 (PUH, PNH, FC); greenish-black dry growth with *H. byssoidea* and *S. Hofmannii* on stones at Navotas, 618, June 18, 1941 (PUH, FC); blackish growth on dried rocks in front of church at Pandacan, 562, August 10, 1940 (PUH, PNH, FC); black growth on damp old walls of the Catholic Church, San Mateo, JDS, May 27, 1952 (PUH, PNH, FC, NY); SORSOGON: in Irosin (Mt. Bulusan): blue-green growth, *A. D. E. Elmer, 17136b*, September, 1916 (PUH, PNH); lichenized growth on leaf, *A. D. E. Elmer, 17068*, August, 1916 (PUH); Manila: blackish feltlike growth with *S. Hofmannii* and *H. byssoidea* on stone walls at the premises of the Philippine Long Distance Telephone Company, Marques de Comillas, 589, January 8, 1941 (PUH, PNH, FC); blackish dark blue-green growth with *H. byssoidea* on stone wall at premises of Philippine Long Distance Telephone Company, Marques de Comillas, 588; January 8, 1941 (PUH, FC); deep greenish with *H. byssoidea* and *S. Archangelli* on stones near Philippine Normal School, 152, November 29, 1939 (PUH, NH, FC); bluish growth on Cavite street, Blumentritt, 2433, July 23, 1950 (PUH, PNH, FC); along Pennsylvania street: very thick, blackish growth with *H. byssoidea* and *S. guyanense* on old stone pillar, 106, November 18, 1939 (PUH, PNH, FC); thick, blackish growth with *H. byssoidea* and *S. guyanense* on old stone walls, 110, November 18, 1939 (PUH, PNH, FC); blackish green growth on stone walls, 146, November 22, 1939 (PUH, PNH, FC); dark blue-green growth in Geliños, Sampaloc, 2438, July 24, 1950 (PUH, PNH, FC); black growth with *H. byssoidea* and *S. guyanense* on bark of *Diospyros discolor* at Padre Faura street, 580, December 17, 1940 (PUH, FC); on UP campus: Department of Botany: dark greenish, sometimes yellowish growth on stone walls of water tank, 156, December 7, 1959 (PUH, PNH, FC); greenish to light bluish to brown growth abundant on walls of water tank, 447, February 21, 1940 (PUH, PNH, FC); deep grayish blue-green growth with *S. javanicum* on stone wall of water tank, *F. Salas* and *G. T. Velasquez 485*, April 2, 1940 (PUH, FC); brownish to black growth with *H. byssoidea* and *S. guyanense* on cemented wall of Alumni Hall Bldg., 582, December 17, 1940 (PUH, PNH, FC); blackish growth with *H. byssoidea* and *S. ocellatum* on cemented wall of Chem. Bldg., 581, December 17, 1940 (PUH, FC); deep greenish-blue growth, *C. B. Robinson 679*, June 28, 1909 (PUH, PNH, NY); Quezon City: in Balara: olive-green to blue-green growth, 2547, August 26, 1950 (PUH, PNH, FC, NY); dark blue-green growth 2554, August 26, 1950 (PUH, PNH, FC); in Kamuning: blackish growth, 2490, January 29, 1950 (PUH, PNH, FC, NY); greenish-blue to black growth, 2494, January 29, 1950 (PUH, PNH, FC, NY); in La Mesa Park, Novaliches: thin, black growth on hillside, 3737, February 8, 1956 (PUH, PNH, FC); dry, thick blackish growth among the grasses on the hillside, 3739, February 5, 1956 (PUH, PNH, FC); on UP campus: greenish-blue growth, 2432, July 22, 1950 (PUH, PNH, FC); black growth, 2527, February 28, 1950 (PUH, PNH, FC, NY).

SCYTONEMA OCELLATUM Lygnbye. Plate 12, fig. 139.

S. ocellatum LYNGBYE, Hydrophytologia Danica (1819) 97, pl. 28a, 4 figs.

Plant mass cushion-shaped, dark yellow, blackish or blue-green; filaments (10–) 13.6 to 18 μ wide, interwoven, flexuous, generally with short false branches; trichomes (6–) 8 to 14 μ wide, olive to yellow-green, enclosed in firm sheaths; cells short to quadrate, heterocysts subquadrate.

Specimens examined.—LUZON: Batangas: in Lipa: blue velvety growth on very dry side of highway at Balete, 372, January 21, 1940 (PUH, FC); dark grayish growth on stones in citrus plantation at Balete, 374, January 21, 1940 (PUH, PNH, FC); Bulacan: very deep blue-green to blackish growth on dry stone walls of cemetery at Calumpit, 428, February 4, 1940 (PUH, FC). PANAY: Iloilo: black growth on old adobe walls of the ruined Catholic church in January, JDS, 1033, June 25, 1952 (PUH, PNH, FC). LUZON: Laguna: dark blue-green growth on the College Campus, 2470, August 14, 1948 (PUH, PNH, FC, NY); greenish-black growth on bark of trees along highway at San Pedro, 654, December 1, 1940 (PUH, PNH, FC); Mountain Province: blackish-green growth with *S. guyanense* on stones along the roadside, Baguio, 236, December 27, 1939 (PUH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: dark blue-green felty growth with yellowish-brown upper surface in poblacion, 1682, April 19, 1948 (PUH, PNH, FC, NY); black growth in Mahabang Parang, 1739, May 5, 1948 (PUH, PNH, FC). LUZON: Pampanga: dark greenish growth on stones along the pathway at Nursery, Arayat, 520, May 22, 1940 (PUH, PNH, FC); Rizal: bluish growth on root debris of a fern pot at Tanay, 436, February 1940 (PUH, FC); blue-green growth on wet rocks at the waterfall, Hinulugang Taktak, Antipolo, 488, May 1, 1940 (PUH, PNH, FC); black woolly growth with *Trentepohlia* sp. on stone wall of rice mill in Marikina, 417, February 2, 1940 (PUH, PNH, FC); dark bluish growth on dry rocks at Montalban, 490, May 1, 1940 (PUH, PNH, FC); Manila: blackish growth on old stone walls along Pennsylvania street, 112, November 18, 1939 (PUH, PNH, FC); blackish-green growth abundant on cement tank of UP Department of Botany, 481, April 6, 1940 (PUH, PNH, FC); Quezon City: in Balara: reddish-purple to greenish-black growth, 2510, February 26, 1950 (PUH, PNH, FC, NY, UC); dark greenish-blue to greenish-black, bluish or brownish-black growth, 2549, August 26, 1950 (PUH, PNH, FC, NY, UC); greenish-black growth in Kamuning, 2539, August 19, 1950 (PUH, PNH, FC).

SCYTONEMA ALATUM Borzi. Plate 12, fig. 140.

S. alatum BORZI in Nuov. Giorn. Bot. Ital. 11 (1879) 373.

Plant mass mucoid, cæspitose, dark yellowish blue-green to ash colored; filaments flexuous, erect within very long, thick lamellose sheaths, often obliquely striated, generally forming wings or membranaceous expansions, contracted at the heterocysts, (24–) 37.4 to 71.4 (–66) μ wide, much dilated, closed at the tips, oftentimes empty, heterocysts 9 to 15 μ wide, constricted at cell joints; cells rectangular, heterocysts globular.

Specimens examined.—LUZON: Rizal: in Montalban: light grayish growth with *S. chalybea* abundant on dry rocks, 493, May 1, 1940 (PUH, PNH, FC); dark yellowish blue-green to blackish and ash-colored growth on cliffs, 3740, February 11, 1956 (PUH, PNH, FC); thick brownish-black velvety growth peeling off the sides of cliff, 3747, February 11, 1956 (PUH, PNH, FC).

SCYTONEMA CRASSUM Nageli. Plate 12, figs. 141 and 141a.

S. crassum NAGELI in Kützing, sp. Alg. (1849) 894.

Plant mass dark to ash blue-green, thick and expanded; filaments erect, flexuous, (27–) 28.9 to 57.8 (–45) μ wide, adpressed, false branching often present; trichomes (9–) 10 to 11.9 (–15) μ thick, within thick, brownish, conspicuously multilamellated; cells generally rectangular, heterocysts globose to subquadrate.

Single specimen examined. — LUZON: Ilocos Norte: black growth on moist rocks beside Banna waterfalls, Banna, 2238, June 5, 1950 (PUH, PNH, FC).

SCYTONEMA MIRABILE (Dillwyn) Bornet.

S. mirabile (Dillwyn) BORNET, Bull. Soc. Bot. Fr. 36 (1889) 155.

Plant mass silky, widely expanded, somewhat spongelike, pale black to deep green; filaments 15 to 21 μ wide, entangled; trichomes 6.5 to 11.5 μ wide, within yellowish, lamellose sheaths; cells long, cylindrical, becoming disc-shaped towards the tip; heterocysts subquadrate.

SCYTONEMA MYOCHROUS Agardh. Plate 12, fig. 142.

S. Myochrous AGARDH, Disp. Alg. Suec. (1812) 38.

Plant mass ragged and woolly, ash-colored, sometimes dark-red, very widely expanded, spongy; filaments tortuous, densely interwoven, (18–) 16.0 to 27.2 (–36) μ wide; trichomes 6 to 10.2 (–12) μ wide, yellow-green, within thick, obliquely lamellose, golden to dark yellow sheaths; cells mostly quadrate, becoming disc-shaped towards tip, contents light yellow-green; heterocysts usually subquadrate.

Specimens examined.—LUZON: Albay: dark blue-green to dark greenish-brown on rocks near waterfalls, Coal Harbor, Carcararay Island, *C. B. Robinson 199*, September 1, 1908 (PUH, PNH, FC); Rizal: in Montalban: dark bluish sometimes pale greenish growth on rocky places, 489, May 1, 1940 (PUH, PNH, FC); dark grayish-black growth on very dry rocks, 494, May 1, 1940 (PUH, PNH, FC).

Genus TOLYPOTHRIX Kutzing, 1843

Filaments flexuous, solitary or developing as soft tufts, expanded; false branches usually arising below the heterocysts; sheaths generally thin and flexible; akinetes globose, oval or elliptic, oftentimes in catenate series.

TOLYPOTHRIX TENUIS Kutzing. Plate 12, fig. 143.

T. tenuis KÜTZING, Phycolog. Gener. (1843) 228.

Plant mass floccose, cushionlike, blue-green when young, becoming light brown or yellow on maturity; filaments (8–) 8.5 to 10.2 (–10) μ wide, entangled, parallel, flexuous or curved, with erect false branches; sheaths thin, hyaline, membranaceous, inflated towards the base; trichomes (6–) 7.4 to 8.5 (–8) μ wide, with cells generally as long as wide and granular protoplasm, heterocysts brown, quadrangular, 1 to 3 (5) in catenate series.

Single specimen examined.—LUZON: Batangas: blue-green, abundant growth along the path of rice field at Balete, Lipa, 596, January 12, 1941 (PUH, PNH, FC).

Family STIGONEMATACEÆ

The habit of branching of the filaments in this family and the manner in which they arise by cell division in a plane parallel to the axis of the primary trichomes distinguish them from the members of the family of the Scytonemataceæ; the trichomes are uniseriate or multi-seriate within sheaths that may be thick and lamellose; cells assume various shapes from quadrate, globose to transversely elliptic; heterocysts are intercalary or lateral and assume various shapes.

Key to the genera of Stigonemataceæ

1. Sheaths definitely conspicuous 2
1. Sheaths not definitely conspicuous .... *Nostochopsis*
    2. Trichomes of one or several rows of cells 3
    2. Trichomes definitely of one row of cells .... *Hapalosiphon*
3. Branches unilateral, trichomes ordinarily uniseriate ..... *Fischerella*
3. Branches scattered, trichomes frequently multiseriate, seldom uniseriate. *Stigonema*

Genus NOSTOCHOPSIS Wood, 1869

Plants forming gelatinous, definitely globose masses in water; branched trichomes variously dispersed, of a single row of cells; heterocysts intercalary, sometimes lateral, sessile or stalked.

NOSTOCHOPSIS LOBATUS Wood. Plate 12, fig. 144.

N. lobatus WOOD, Proc. Amer. Philo. Soc. Phila. (1869) 126.

Plant mass usually vesiculous-lobate, hollow especially when matured, sometimes flat, yellow to blue-green; trichomes variously bent or curved, (4–) 2.6 to 5.1 (–9) μ wide, light blue-green; branches solitary, elongate, flexuous, also light blue-green; cells twice longer than wide, constricted at cell joints; heterocysts intercalary, sessile or stalked.

Specimens examined.—LUZON: Bataan: attached to rocks in streams near "Second Station," Lamao Forest Reserve, W. R. Shaw, April 29, 1907 (PUH). PALAWAN: greenish-black growth in Araceli, 2933, June 15, 1951 (PUH, PNH); dark blue-green growth in Banga River, Coron, 2781, June 3, 1951 (PUH, PNH, FC); Quezon City: yellowish-green to brownish-green to deep blue-green growth in Balara, 2480, March 13, 1949 (PUH, PNH, FC).

Genus HAPALOSIPHON Nageli in Kutzing, 1849

Generally aquatic in habitat; developed as creeping filaments generally of a single series of cells; main trichomes long and flexuous, tapering towards apices, unilaterally branched, branches at right angle with and as wide as the main trichomes; heterocysts intercalary.

HAPALOSIPHON LAMINOSUS Hansgrig. Plate 13, fig. 145.

H. laminosus HANSGRIG, Bot. Centr. (1885) 48.

Plant mass compact, expanded, irregular, sometimes slightly calcified, blue-green; filaments closely or loosely interwoven, generally (6) 5.0 μ wide, torulose, constricted at cell joints, of a single, seldom double, row of cells; branches solitary, erect, sheaths evaginate; cells depressed, spherical or cylindrical to barrel-shaped; heterocysts spherical to oblong, conspicuous and wider than vegetative cells.

Specimens examined.—LUZON: Laguna: light greenish-blue to blue-green growth in hot spring, Los Baños, 2531, March 6, 1950 (PUH, PNH, FC, NY). MINDORO: Oriental Mindoro: blackish dull blue-green growth in Bisayaan, 1762, April 12, 1948 (PUH, PNH, FC).

Genus FISCHERELLA Gomont, 1895

Filaments forming continuous, much expanded layer on terrestial habitat, primary filaments much branched, creeping, secondary filaments slender, usually forming hormogones; cells quadrate or cylindrical.

FISCHERELLA AMBIGUA (Nageli) Gomont. Plate 13, fig. 146.

F. ambigua (Nageli) GOMONT in Morot, Jour. Bot. (1895) 49, pl. 3.

Plant mass cushion-shaped, purple to blue-green; filaments ochreate, flexuous, parallel or loosely intertwined, (6–) 5.1 to 7.7 (–9) μ wide; trichomes 4.3 to 6.8 μ wide, yellow-ochreate to blue-green, within firm hyaline sheaths; false branches solitary, long and flexuous; heterocysts rectangular.

Specimens examined.—LUZON: Batangas: brownish-black growth drying on walls of churchyard at Lipa, 602, January 21, 1941 (PUH, PNH, FC); Laguna: blue-green encrustments on stones kept moist by dripping water at students' toilet, Forestry Camp, Los Baños, 385, January 28, 1940 (PUH, PNH, FC); blue-green growth with *S. violacea, Chroothece monococca* on embankment of a pool at Los Baños, 387, January 28, 1940 (PUH, FC); Mountain Province; in Baguio: blackish growth on soil near Pines Hotel, 194, December 27, 1939 (PUH, PNH, FC); blackish growth along embankment of Kisad Road, 198, December 28, 1939 (PUH, PNH, FC). MINDORO: Oriental Mindoro: in Puerto Galera: dull blue-green growth on dry soil of small hill at Small Tabinay, 736, April 7, 1941 (PUH, PNH, FC); blackish growth along path near stream at Small Tabinay, 738, April 7, 1941 (PUH, PNH, FC); brownish growth on rocks along highway near waterfall bridge, Bisayaan, 1955, May 25, 1949 (PUH, PNH, FC). PALAWAN: brownish-black growth in Tapun, 2897, June 20, 1951 (PUH, PNH, FC). LUZON: Rizal: dark brown growth on adobe stones in front of Antipolo church, 3765, February 20, 1956 (PUH, PNH, FC); Manila: dried woolly growth along parkway at Dewey Boulevard, 89, November 12, 1939 (PUH, PNH, FC); Quezon City: greenish-blue growth in UP campus, 2459, July 29, 1950 (PUH, PNH, FC).

Genus STIGONEMA Agardh, 1824

Filaments generally multiseriate, rarely uniseriate, terrestrial and aquatic, irregular spreading habit conspicuous; sheaths usually wide, homogeneous or lamellose; heterocysts lateral and intercalary; hormogones present.

Key to the species of Stigonema

1. Trichomes in the mature filaments of a single row of cells 2
1. Trichomes in the mature filaments of several rows of cells; filaments 18 to 29 μ wide .... *S. minutum*
    2. Filaments 7 to 51 μ wide; sheaths not lamellose and generally colorless .... *S. hormoides*
    2. Filaments wider; sheaths lamellose and generally colored .. 3
3. Filaments 24 to 26 μ wdie, usually tapering; cells globose to depressed globose .... *S. panniforme*
3. Filaments wider, not usually tapering; cell shape and size variable. *S. ocellatum*

STIGONEMA MINUTUM Hassall. Plate 13, fig. 147.

S. minutum HASSALL, Hist. Brit. Fr. Alg. 1 (1852) 230, pl. 67, figs. 3, 4.

Plant mass thin, cushion-shaped, fragile, dark blue-green; filaments decumbent at base, ascending gradually towards apices, long branches 18 to 28 μ wide, flexuously curved, short branches stout and as large as the primary filaments; hormogones abundant, sheaths yellow and lamellose; heterocysts numerous, lateral and intercalary.

Single specimen examined.—LUZON: Mountain Province: forming a blackish or purplish coating with *S. figuratum* on surface of embankment along Session Road, Baguio, 199, December 28, 1939 (PUH, PNH, FC).

STIGONEMA HORMOIDES Bornet and Flahault.

S. hormoides BORNET and FLAHAULT, Ann. Sci. Nat. VII 5 (1887) 68.

Plant mass thin, silky, dark blue-green; filaments (7–) 9 to 13 (–15) μ wide, decumbent, densely entangled, with erect branches as large as the primary filaments; sheaths thick, colorless; cells spherical in a single row, very rarely in a double row; heterocysts rare.

STIGONEMA PANNIFORME Bornet and Flahault. Plate 12, fig. 148.

S. panniforme BORNET and FLAHAULT, Ann. Sci. Bot. VII 5 (1887) 71.

Plant mass expanded, cushion-shaped, rust-reddish to olive-green; filaments decumbent, somewhat flexuous, entangled, (24–) to 28.9 to 34.9 (–36) μ wide, tapering at apices, with thick, yellow and lamellose sheaths; cells globose or depressed-globose, somewhat far apart, usually uniseriate, blue-green; heterocysts rare, hormogones frequently towards the younger portion.

Single specimen examined.—LUZON: Quezon Province: blue-green growth with a *Stigonema* sp. in the Island of Polillo, *C. B. Robinson,* August, 1909 (PUH).

STIGONEMA OCELLATUM Thuret. **Plate 13, figs. 149 and 149a.**

S. ocellatum THURET, Ann. Sci. Nat., Bot. ser. 6e 1 (1875) 580.

Plant mass growing among other algæ; cushion-shaped, ragged and tomentose; filaments decumbent at base, irregularly branched, erect towards apices; primary filaments (35–) 30.6 to 37.4 (–45) μ wide; sheaths thick, dark and lamellose; hormogones present.

Single specimen examined.—LUZON: Mountain Province: purplish-brown growth with *P. Notarisii,* C. B. Robinson, August, 1909 (PUH).

REFERENCES

1. BHARADWAJA, YAJNAVALKYA. Contributions to our knowledge of the Myxophyceæ of India. Ann. Bot. (185) **47** (1933).
2. BHARADWAJA, YAJNAVALKYA. The taxonomy of Scytonema and Tolypothrix, including some new records and new species from India and Ceylon (1934). Extr. Rev. Algol. (1–2) (1933).
3. BHARADWAJA, YAJNAVALKYA. Some aspects of the study of the Myxophyceæ. Proc. Ind. Sci. Cong., Part 2 (1940).
4. BORNET, E., and C. FLAHAULT. Revision des Nostocacees Heterocystees. Ann. Sci. Natur. VII Ser. Bot. Tomes III, IV, V, et VII (1886–1888).
5. DESIKACHARY, T. V. Cyanophyta. Indian Council of Agricultural Research, New Delhi, India (1956) 686 pp., 139 plates.
6. DETONI, G. B. Silloge algarum omnium hucusque cognitarum. I. Padua. 1907. Ibid. Myxophyceæ **5** (1889) (A. Forti). Padua.
7. DROUET, FRANCIS, and WILLIAM A. DAILY. Revision of the Coccoid Myxophyceæ. Butler Univ. Bot. Stud. **12** (1956).
8. FREMY, PIERRE. Les Cyanophycees des Cotes d'Europe, avec 66 planches. Mem. Soc. Nat. Sci. Natur. Math. Cherb. **41** (1934) 1–236.
9. GARDNER, NATHANIEL L. New Myxophyceæ from Porto Rico in Memoirs of the New York Botanical Garden **7** (1927) 1–144, 23 plates, 161 figs.

10. GEITLER, LOTHAR. Cyanophyceæ in A. Pascher's Die Susswasser-flora Deutschlands, Osterreichs und der Schweiz **12** (1925) 1–450.

11. GEITLER, LOTHAR. Cyanophyceæ. Akad. Verlag. m. b. H., Leipzig (1932) 1–1196, 780 figs.

12. GOMONT, M. MAURICE. Monographie des Oscillariees (Nostocaceæ, Homocystees) (1893).

13. SORIANO, JOVENTINO D. Myxophyceæ of Panay and Negros Islands. Nat. App. Sci. Bull. (1 & 2) **8** (1953) 3 pls., 22 figs.

14. SORIANO, JOVENTINO D., and G. T. VELASQUEZ. Studies on the Myxophyceæ of Manila and vicinity. Nat. App. Sci. Bull. (1) **12** (1952) 3–89, 4 pls., 36 figs.

15. TILDEN, JOSEPHINE. Minnesota Algæ **1** (1910).

16. VELASQUEZ, GREGORIO T. Studies on the Myxophyceæ of Puerto Galera and vicinity. Nat. App. Sci. Bull. (4) **10** (1950) 309–328.

17. VELASQUEZ, GREGORIO T. Additional record of Philippine Myxophyceæ. Nat. App. Sci. Bull. (3 & 4) **11** (1951) 208–229.

18. VELASQUEZ, GREGORIO T. The ecological distribution of the myxophycean algæ in eastern Palawan and Sulu Province. Nat. App. Sci. Bull. (2–4) **15** (1955) 153–184, 5 pls.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Agmenellum thermale* (Kützing) Drouet & Daily.
2. *Coccochloris stagnina* Sprengel.
3. *C. Peniocystis* Drouet & Daily.
4. *Anacystis cyanea* Drouet & Daily.
5. *A. montana* f. *montana* Drouet & Daily.
6. *A. dimidiata* Drouet & Daily.
7. *A. æruginosa* Drouet & Daily.
8. *A. thermalis* f. *thermalis* Drouet & Daily.
9. *Entophysalis conferta* Drouet & Daily.
10. *E. Lemaniæ* f. *Lemaniæ* Drouet & Daily.
11. *Stichosiphon sansibaricus* Drouet & Daily.
12. *Spirulina major* Kützing.
13. *S. subsalsa* Oersted.
14. *Oscillatoria* princeps Vaucher.
15. *O. proboscidea* Gomont.
16. *O. Bonnemaisonii* Crouan.
17. *O. Corallinea* Gomont.
18. *O. ornata* Kützing.
19. *O. tenuis* Agardh.

(All figures, × 810.)

PLATE 2

FIG. 20. *Oscillatoria tenuis* Agardh.
21. *O. sancta* Kützing.
22. *O. limosa* Agardh.
23. *O. margaritifera* Kützing.
24. *O. nigro-viridis* Thwaites.
25. *O. salinarum* Collins.
26. *O. formosa* Bory
27. *O. geminata* Meneghini.
28. *O. acuminata* Gomont.
29. *O. Okeni* Agardh.
30. *O. anguina* Bory.
31. *O. brevis* Kützing.
32. *O. Willei* Gardner.
33. *O. Grunowiana* Gomont.
34. *O. terebriformis* Agardh.
35.–35b. *O. splendida* Greville.
36. *O. animalis* Agardh.
37. *O. articulata* Gardner.
38. *O. granulata* Gardner.
39. *O. amphibia* Agardh.
40. *O. chlorina* Kützing.

41. *Phormidium persicinum* Gomont.
42. *P. molle* Gomont.
43. *P. minnesotense* (Tilden) Drouet.
44. *P. tenue* Gomont.
45. *P. luridum* Gomont.
46. *P. Crosbyanum* Tilden.

(All figures, × 810.)

PLATE 3

FIG. 47. *Phormidium purpurascens* Gomont.
48. *P. valderianum* Gomont.
49. *P. treleasei* Gomont.
50. *P. ambiguum* Gomont.
51. *P. uncinatum* Gomont.
52. *P. favosum* Gomont.
53. *P. autumnale* Gomont.
54. *P. subfuscum* Kützing.
55. *P. Retzii* Gomont.
56. *P. inundatum* Kützing.
57. *P. papyraceum* Gomont.
58. *Symploca læte-viridis* Gomont.
59. *S. hydnoides* Gomont.
60. *S. Muscorum* Gomont.
61. *S. muralis* Kützing.
62. *S. elegans* Kützing.
63. *S. parietina* Gomont.
64. *Lyngbya sordida* Gomont.
65. *L. æstuarii* Liebmann.
66. *L. semi-plena* J. Agardh.
67. *L. confervoides* A. Agardh.

(All figures, × 810.)

PLATE 4

FIG. 68. *Lyngbya majuscula* Harvey.
69. *L. putealis* Montagne.
70. *L. versicolor* Gomont.
71. *Porphyrosiphon Notarisii* Kützing.
72. *P. fuscus* Gomont.
73. *P. Velasquezii* Drouet.
74–74a. *Schizothrix Stricklandii* Drouet.
75–75a. *S. rubella* Gomont.
76–76a. *S. calcicola* Gomont.

(Figures 68–73, 74a, 75a, and 76a, × 810; the rest, × 355.)

PLATE 5.

FIG. 77–77a. *Schizothrix lardacea* Gomont.
78–78a. *S. lateritia* Gomont.
79–79a. *S. tinctoria* Gomont.
80–80a. *S. Lamyi* Gomont.

81–81a. *S. thelephoroides* Gomont.
82. *S. acuminata* (Gardner) Drouet.

(Figures 77a, 78, 78a, 79a, 80a, and 82, × 810; the rest, × 355.)

PLATE 6

FIG. 83–83a. *Schizothrix chalybea* Gomont.
84–84a. *S. purpurascens* Gomont.
85–85a. *Microcoleus tenerrimus* Gomont.
86. *M. chthonoplastes* Thuret.
87–87a. *M. lacustris* Farlow.
88–88a. *M. rupicola* (Tilden) Drouet.
89–89a. *M. acutissimus* Gardner.
90–90a. *M. vaginatus* Gomont.

Figures 83a, 84a, 85a, 86, 87a, 88a, 89a, and 90a, × 810; the rest, × 355.)

PLATE 7

FIG. 91–91a. *Microcoleus paludosus* Gomont.
92. *Hydrocoleum glutinosum* Gomont.
93. *H. cantharidosmum* Gomont.
94. *H. lyngbyaceum* Kützing.
95. *Nostoc carneum* Agardh.
96. *N. ellipsosporum* Rabenhort.
97. *N. Muscorum* Agardh.
98. *N. cuticulare* Bornet & Flahault.
99. *N. verrucosum* Vaucher.

(All figures, × 810 except figures 91 and 93, × 355.)

PLATE 8

FIG. 100. *Nostoc calcicola* Brebisson.
101. *N. humifuscum* Carmichæl.
102. *N. piscinale* Kützing.
103. *N. maculiforme* Bornet & Flahault.
104. *N. Linckia* Bornet.
105. *N. commune* Vaucher.
106. *N. pruniforme* Agardh.

(All figures, × 810.)

PLATE 9

FIG. 107. *Nostoc microscopicum* Carmichæl.
108. *N. rivulare* Kützing.
109. *Anabæna unispora* Gardner.
110. *A. sphærica* Bornet & Flahault.
111. *A. variabilis* Kützing.
112. *A. oscillarioides* Bory.
113. *A. inequalis* Bornet & Flahault.
114. *Cylindrospermum catenatum* Ralfs.
115. *C. stagnale* Bornet & Flahault.
116–116a. *C. majus* Kützing.

117. *C. licheniforme* Kützing.
118. *C. muscicola* Kützing.
119. *Aulosira implexa* Bornet & Flahault.

(All figures, × 810.)

PLATE 10

FIG. 120. *Hormothamnion enteromorphoides* Grunow.
121–121a. *H. solutum* Bornet & Grunow.
122. *Amphithrix janthina* Bornet & Flahault.
123–123a. *Calothrix pilosa* Harvey.
124. *C. parietina* Thuret.
125. *C. confervicola* Agardh.
126. *Isactis plana* Thuret.
127. *Rivularia bullata* Berkeley.
128–128b. *Gardnerula corymbosa* (Harvey) J. de Toni.

(Figures 120–122, 123a–124, 126, and 127, × 810; 123, 125, and 128b, × 355; 128, × 44 and 128a, × 83.)

PLATE 11

FIG. 129. *Brachytrichia Quoyi* Bornet & Flahault.
130. *Plectonema* Wollei Farlow.
131. *P. purpureum* Gomont.
132. *P. Nostocorum* Bornet & Thuret.
133–133a. *Scytonema tolypothricoides* Kützing.
134–134a. *S. coactile* Montagne.
135. *S. cincinnatum* Thuret.
136. *S. stuposum* Bornet.

(Figures 129–133a and 134a, × 810; the rest, × 355.)

PLATE 12

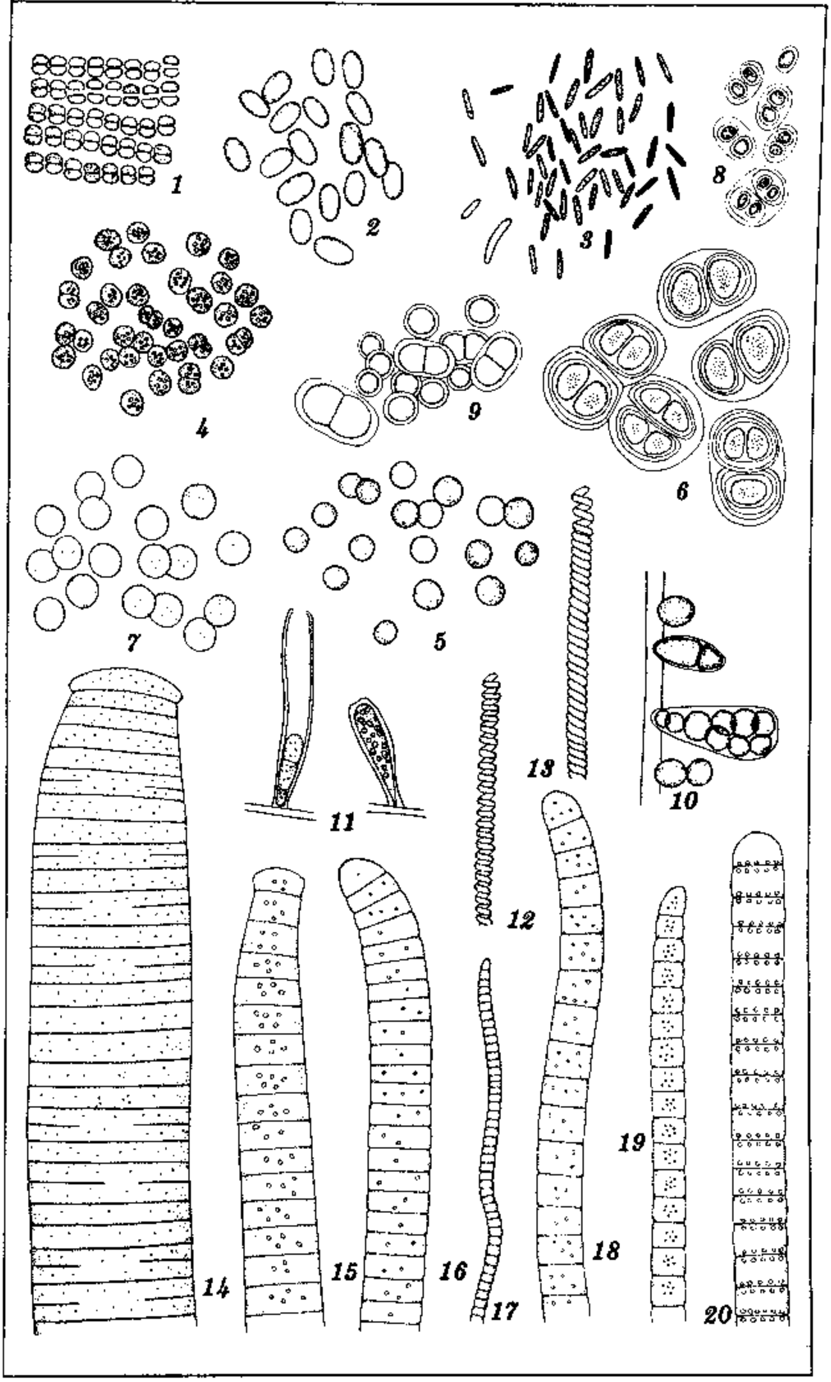
FIG. 137–137a. *Scytonema guyanense* Bornet & Flahault.
138. *S. Hofmannii* Agardh.
139. *S. ocellatum* Lynbye.
140. *S. alatum* Borzi.
141. *S. crassum* Nageli.
142. *S. Myochrous* Agardh.
143. *Tolypothrix tenuis* Kützing.

(Figures 137a, 141a, and 143, × 810; the rest, × 355.)

PLATE 13

FIG. 144. *Nostochopsis lobatus* Wood.
145. *Hapalosiphon laminosus* Hansgrig.
146. *Fischerella ambigua* (Nageli) Gomont.
147. *Stigonema minutum* Hassall.
148. *S. panniforme* Bornet & Flahault.
149–149a. *S. ocellatum* Thuret.

(Figures 144–146; × 810; the rest, × 355.)



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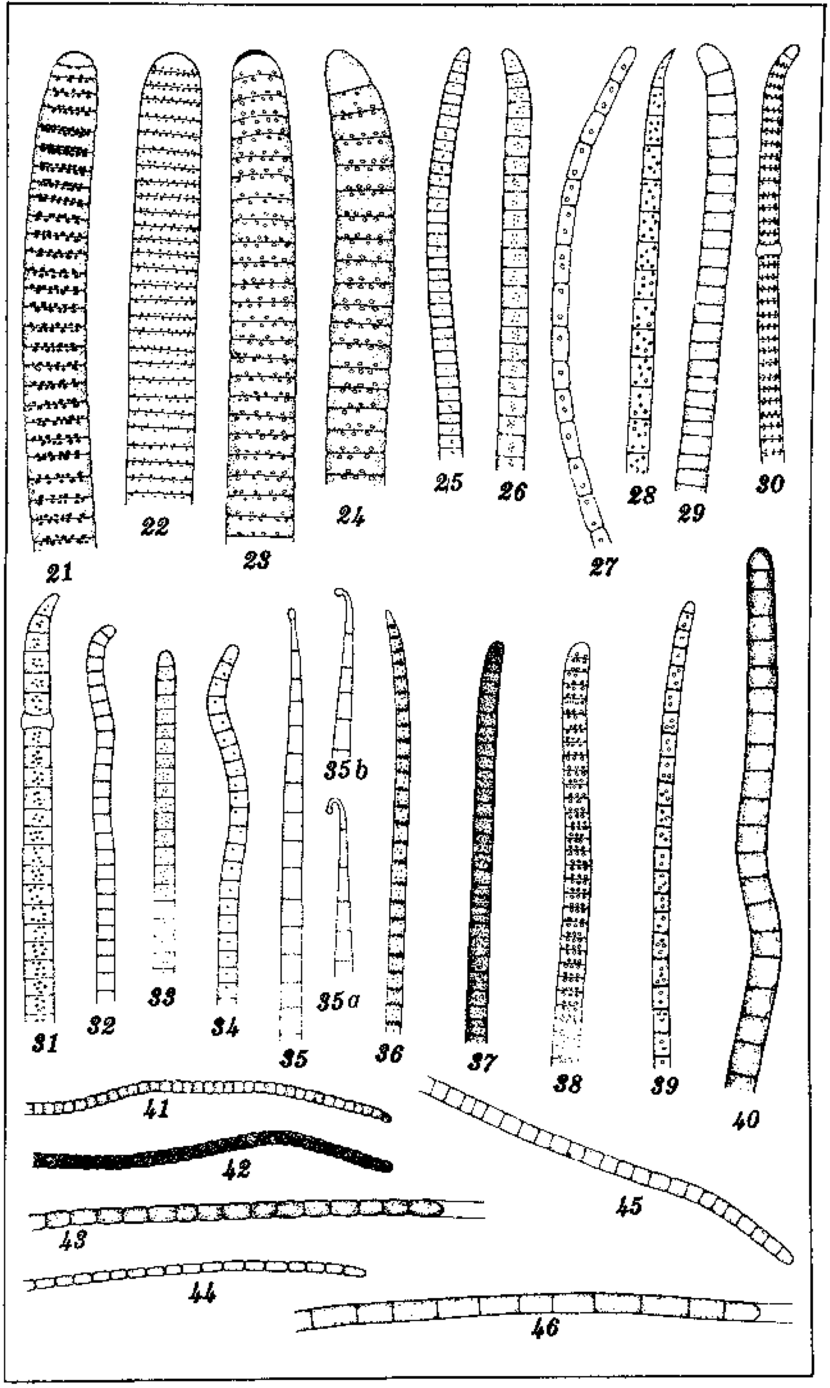

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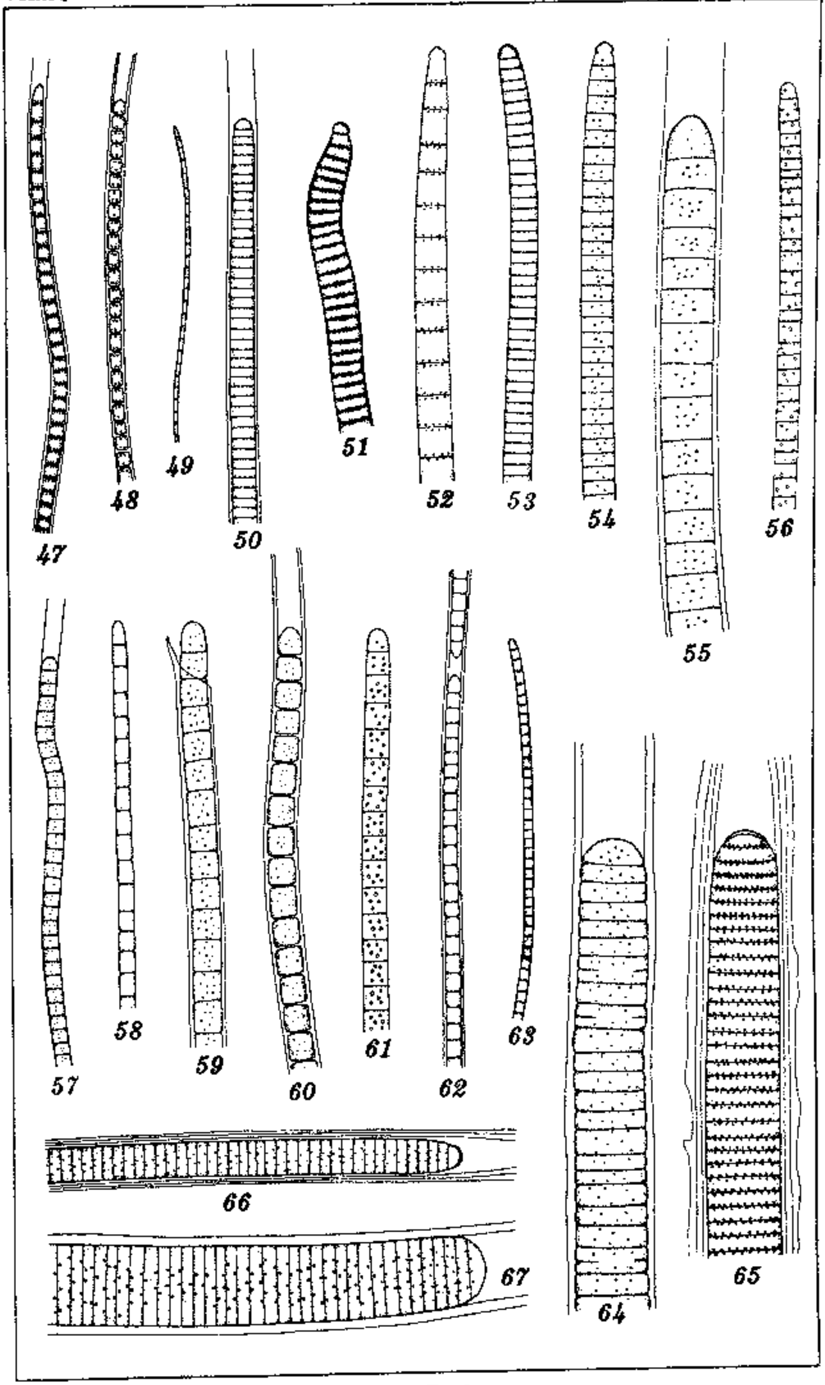

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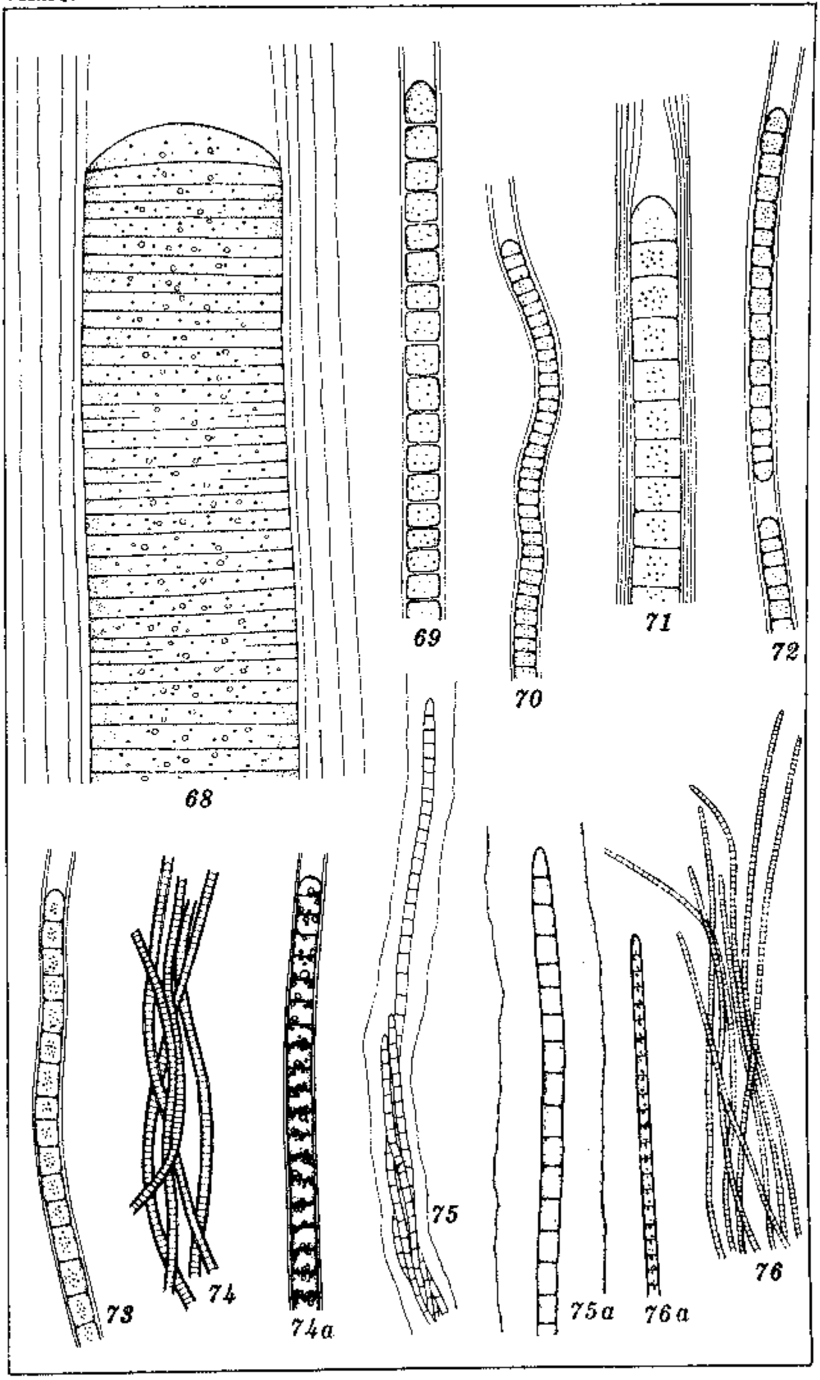

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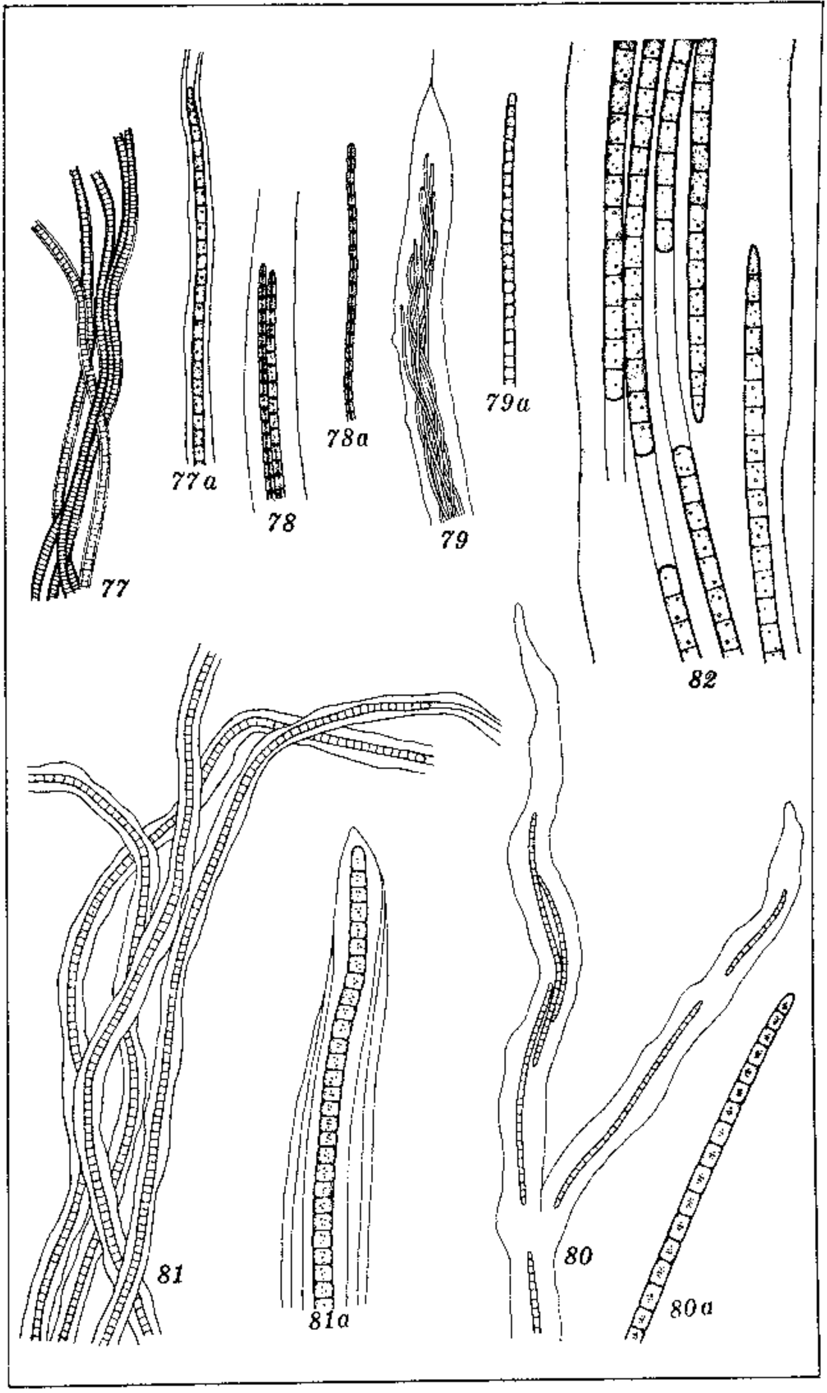

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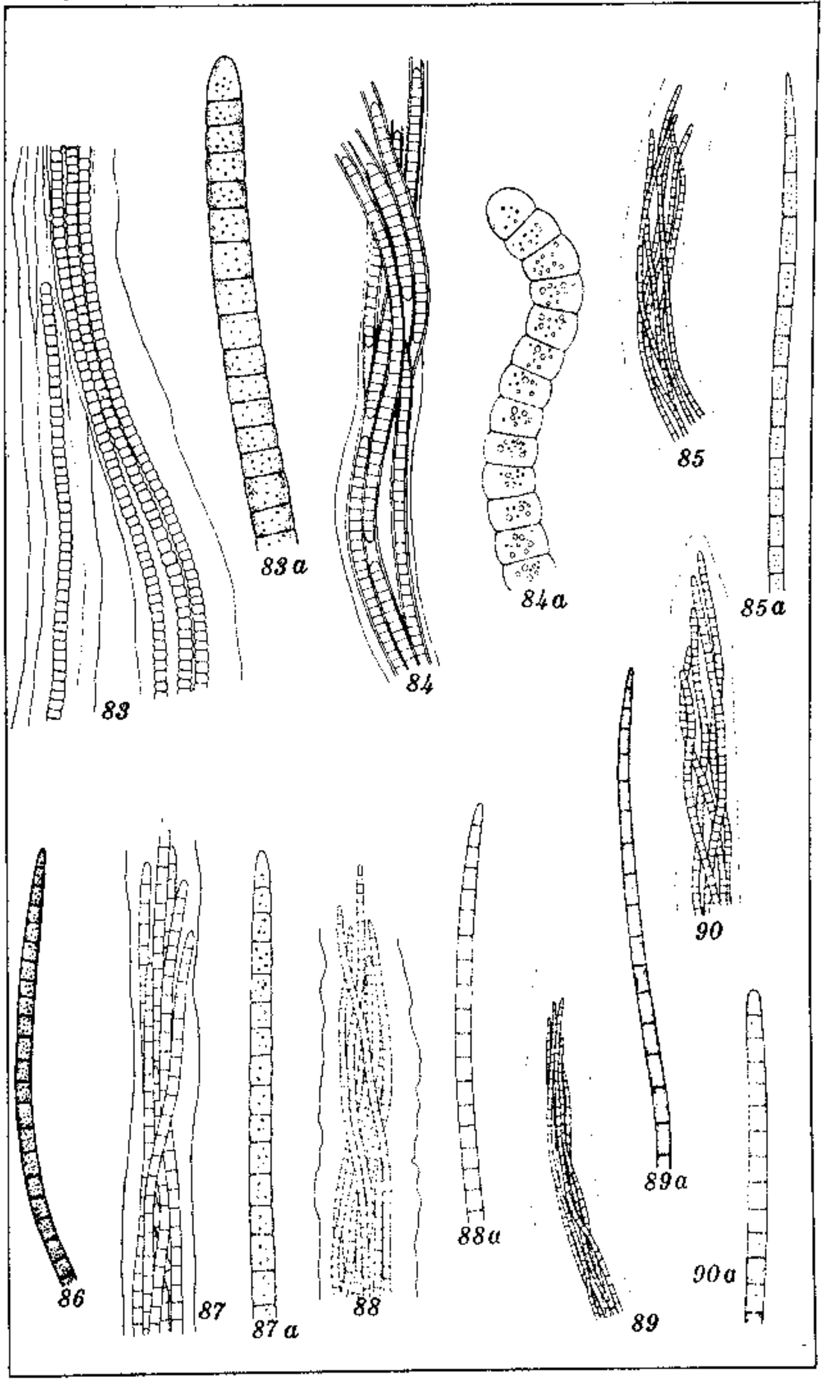

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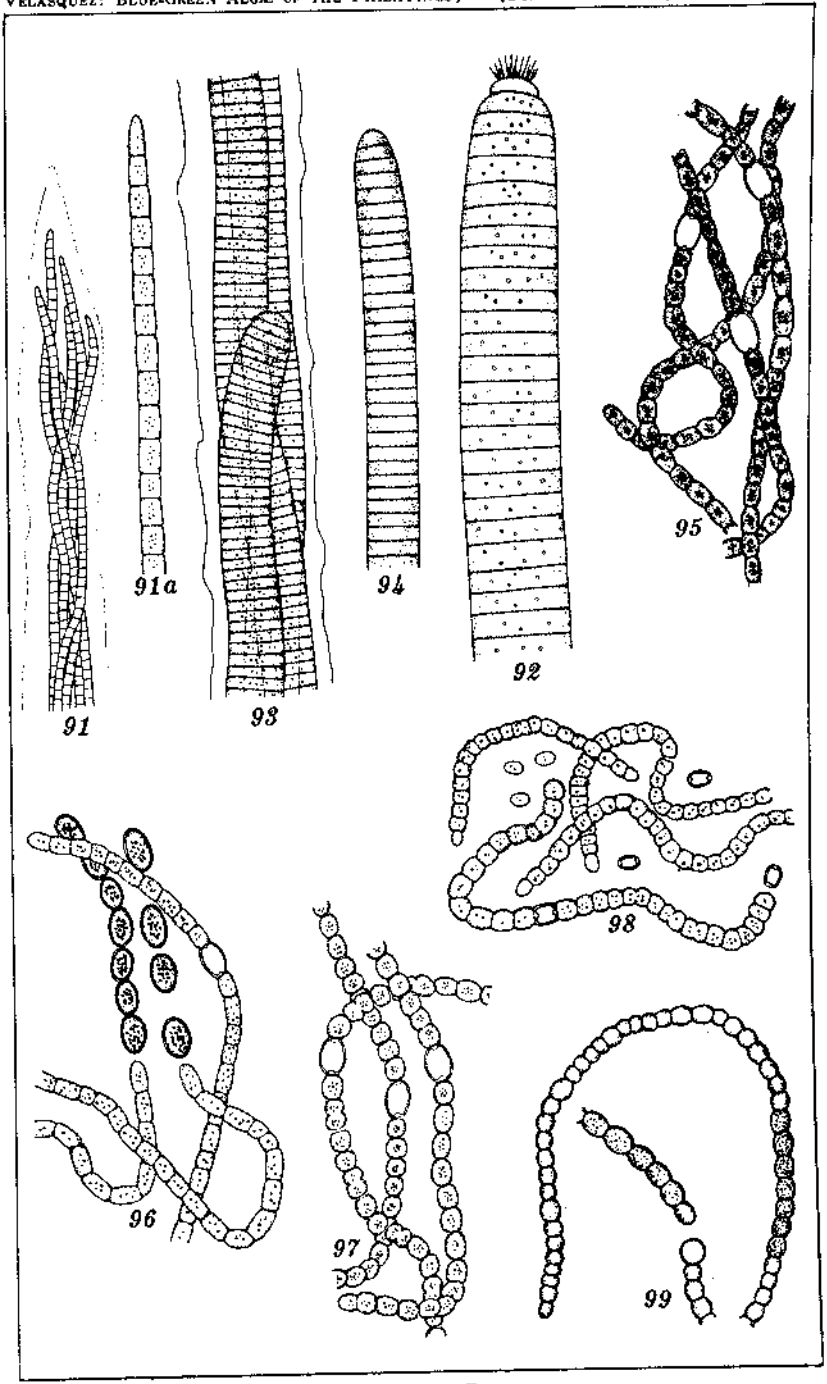

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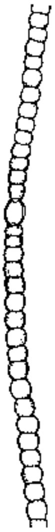

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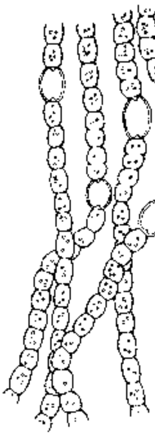

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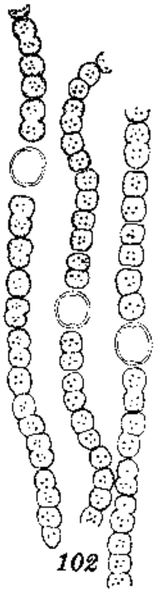

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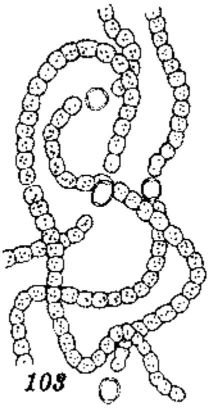

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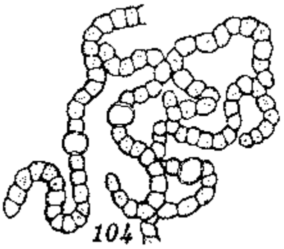

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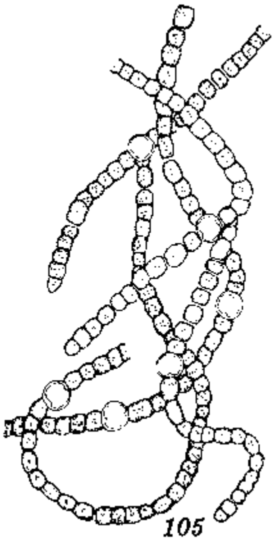

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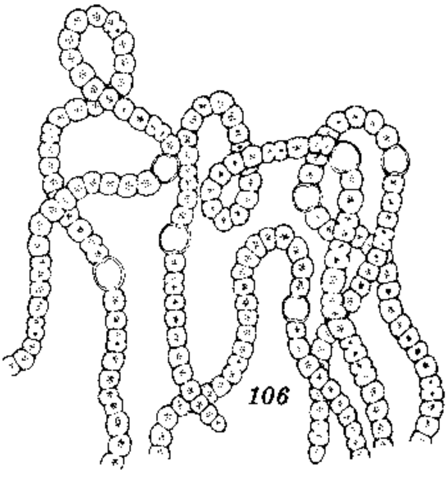

106

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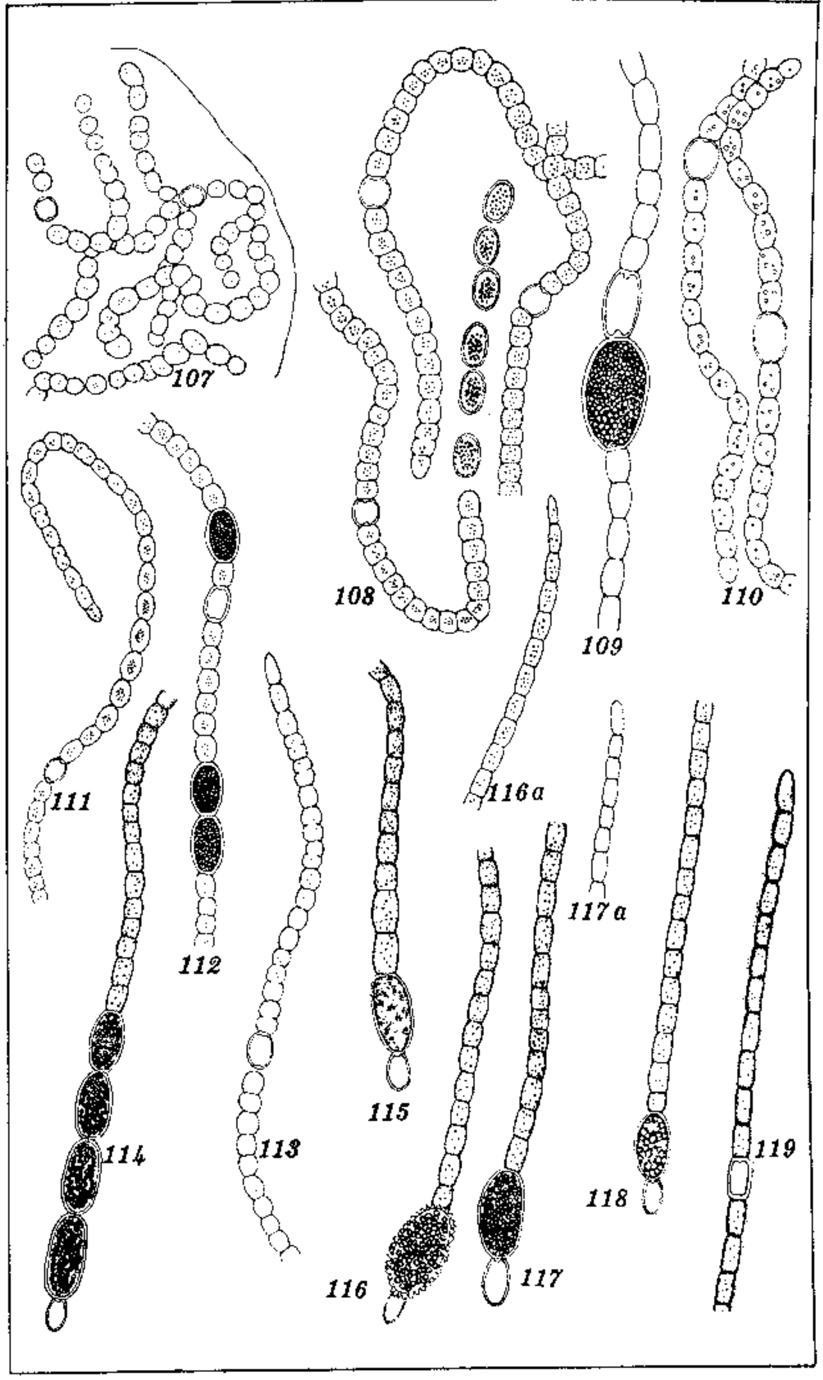

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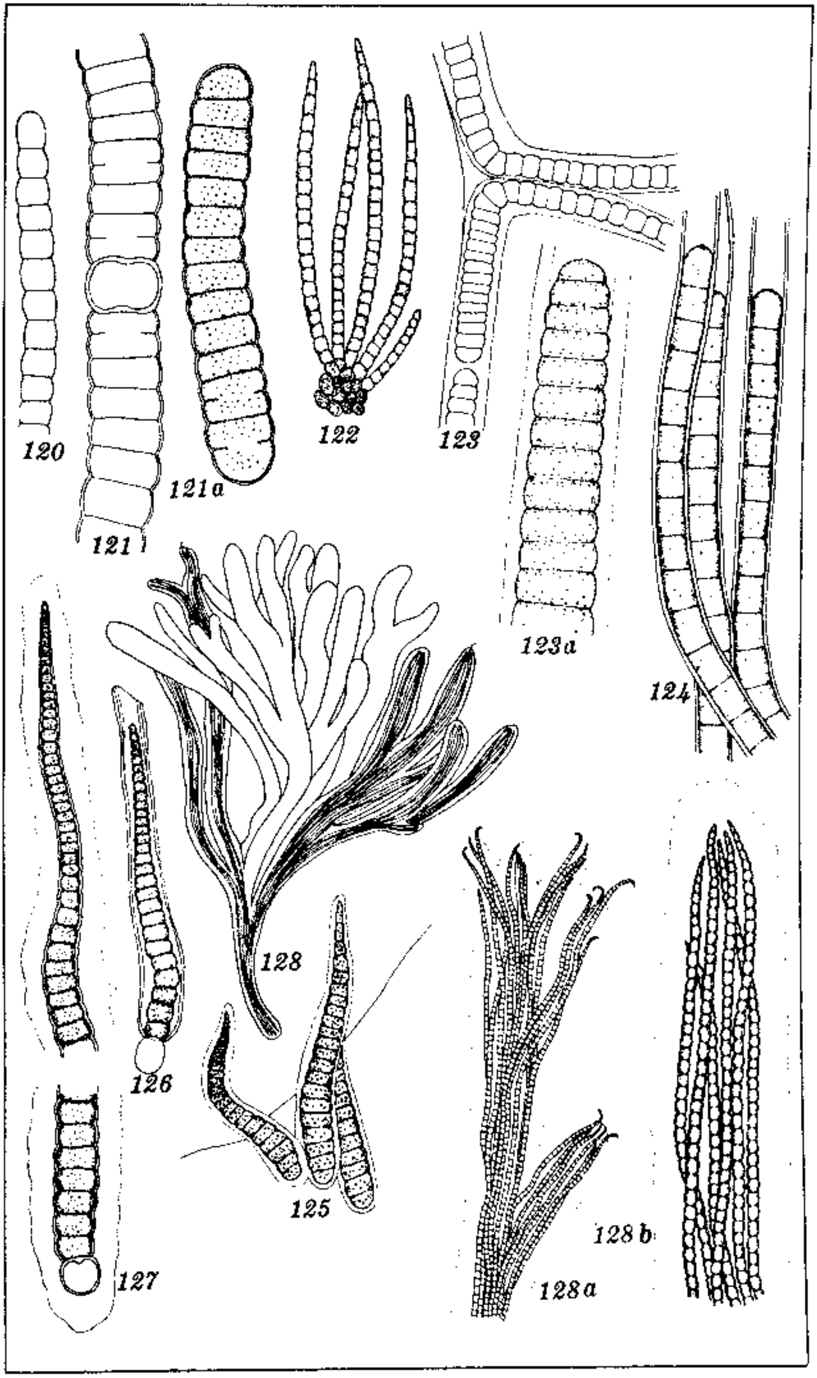

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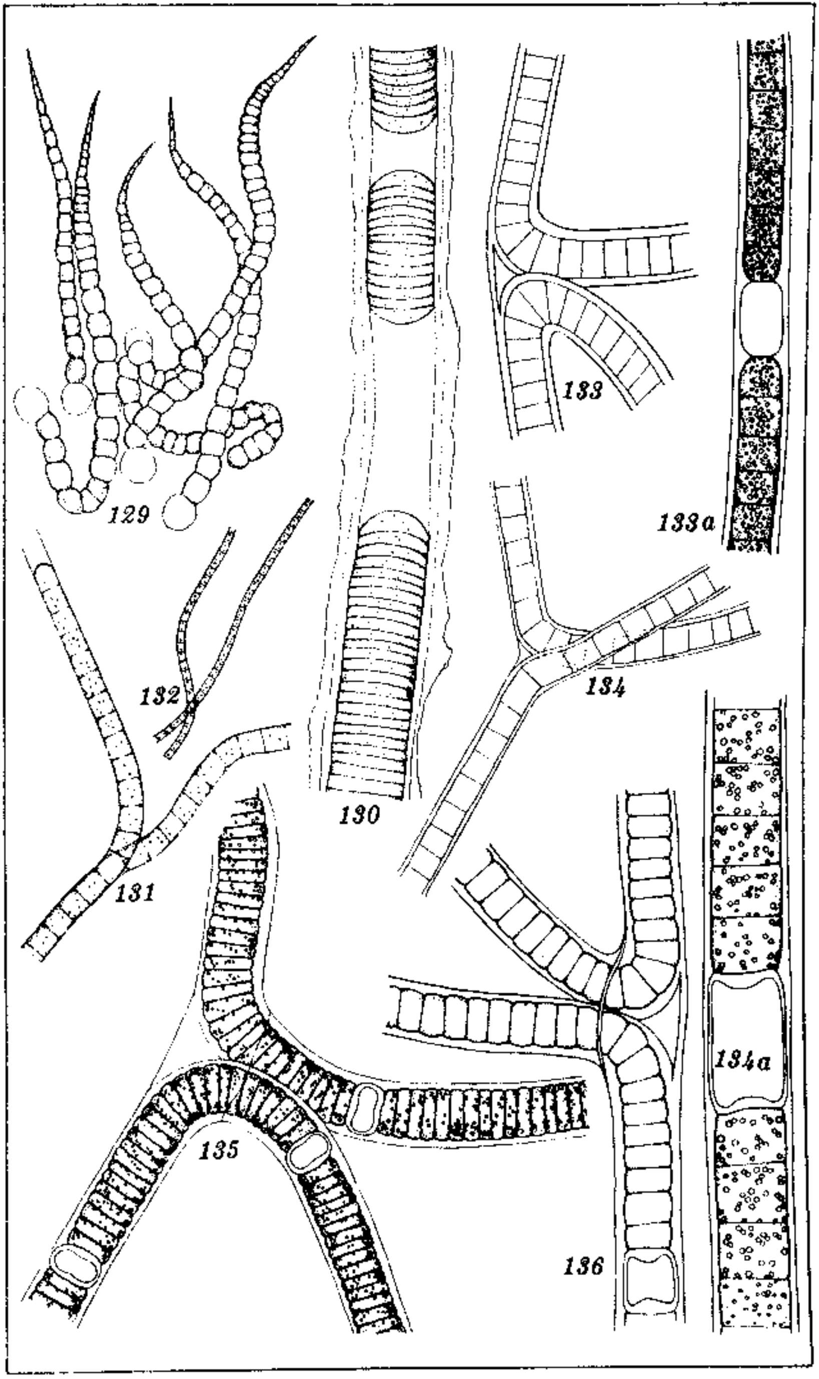

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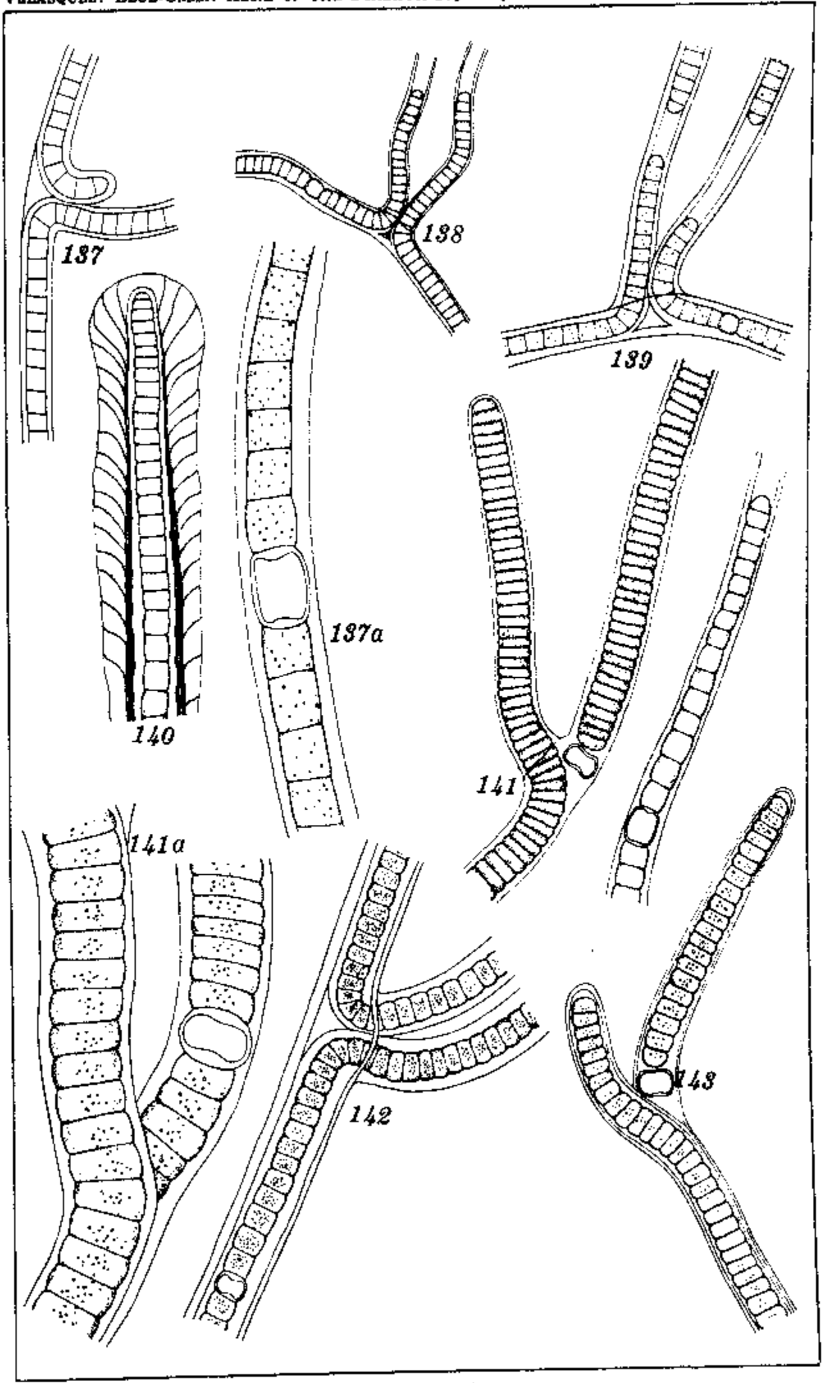

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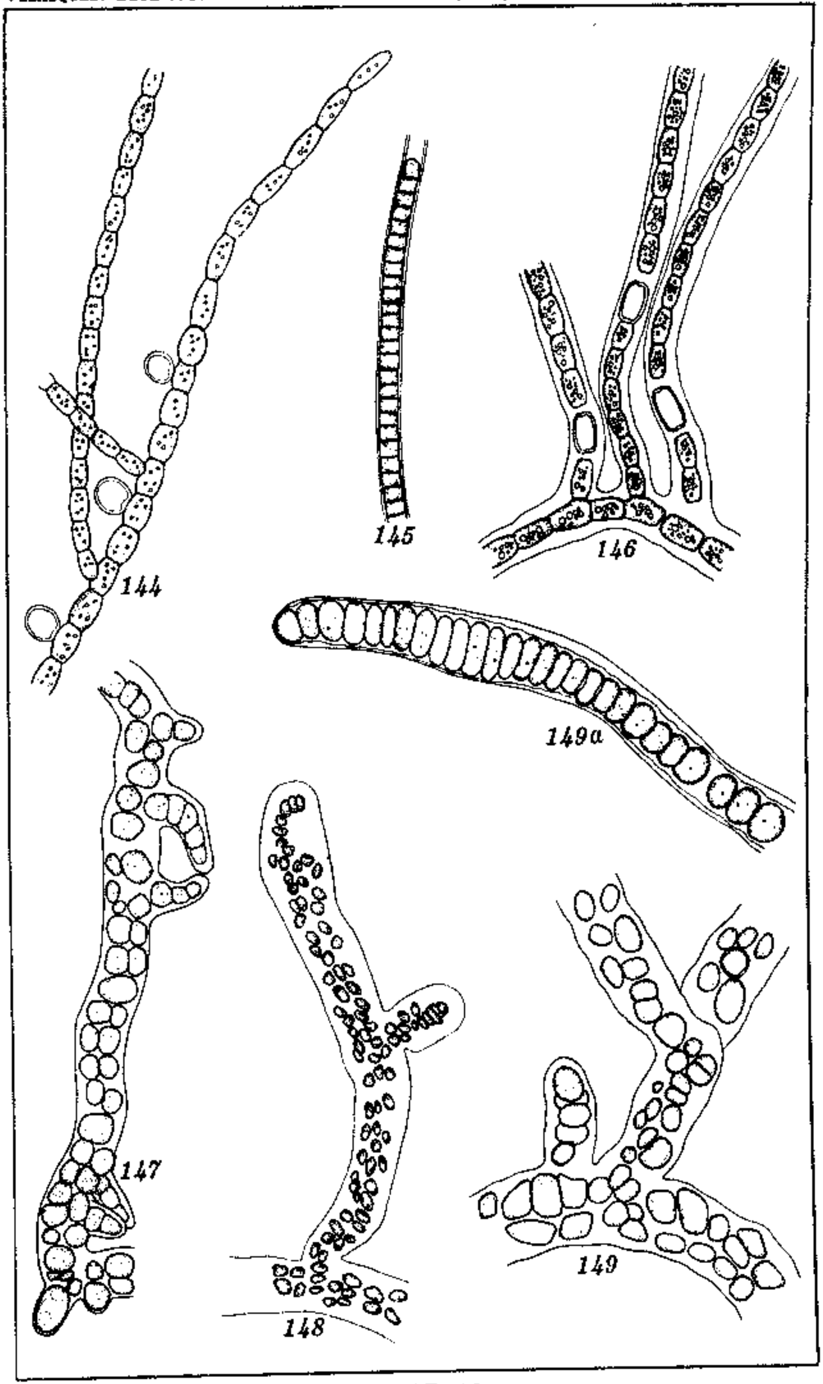

PLATE 13

PUBLICATIONS AVAILABLE

CONTENTS AND INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 1 (1906) to vol. (1915). Bureau of Science Publication No. 8 (1917). Paper, 442 pages. Price, $2.00, United States currency, postage extra.

SECOND TEN-YEAR INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 11 (1916) to vol. 28 (1925). Compiled by Winifred I. Kelley. Bureau of Science Monograph 26. Paper, 382 pages. Price, $2.00, United States currency, postage extra.

CHECKLIST OF THE ANTS (HYMENOPTERA: FORMICIDÆ) OF ASIA. By J. W. Chapman and S. R. Capco. Institute of Science and Technology Monograph 1 (1951) new series. Paper, 327 pages. Price, $2.00, United States currency, postage extra.

NOTES ON PHILIPPINE MOSQUITOES, XVI. GENUS TRIPTEROIDES. By F. E. Baisas and Adela Ubaldo-Pagayon. Institute of Science and Technology Monograph 2 (1952) new series. Paper, 198 pages with 23 plates and 4 text figures. Price, $2.50, United States currency, postage extra.

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CONTENTS

SANTOS, PATROCINIO SEVILLA, and WALFRIDO DE LEON. A survey of Philippine soils for antibiotic-producing streptomyces 241

BIROSEL, D. M., A. L. GONZALES, and M. P. SANTOS. Critical study of the saponification values of naturally occurring fats and oils 255

VELASQUEZ, GREGORIO. The blue-green algæ of the Philippines 267

PUBLICATIONS AVAILABLE—Continued.

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SECURING AQUATIC PRODUCTS IN SIATON MUNICIPALITY, NEGROS ORIENTAL PROVINCE, PHILIPPINES. By Donn V. Hart. Institute of Science and Technology Monograph 4 (1956) new series. Paper, 84 pages with 22 text figures and 8 plates. Price, $1.25, United States currency, postage extra.

AN ECOLOGICAL STUDY OF THE KOUPREY, NOVIBUS SAUVELI (URBAIN). By Charles H. Wharton. Institute of Science and Technology Monography 5 (1957) new series. Paper, 111 pages with 11 plates and 16 text figures. Price, $1.25, United States currency, postage extra.

FERN FLORA OF THE PHILIPPINES. By Edwin B. Copeland. Institute of Science and Technology Monograph 6, Vols. 1–3 (1958–1960) new series. Vol. 1, 191 p., Paper, Price, $1.25; Vol. 2, 193–376, p., Paper, Price, $1.75; Vol. 3, 377–557 p., Paper, Price, $1.75, United States currency, postage extra.

THE PHILIPPINE PIMPLINI, POEMENIINI, RHYSSINI, AND XORIDINI. By Clare R. Baltazar. National Institute of Science and Technology Monograph 7 (1961) new series. Paper, 129 pages with four plates. Price $1.50, United States currency, postage extra.

THE PHILIPPINE INDEX MEDICUS. Volume 3. By Aquilino Y. Argosino. National Institute of Science and Technology Special Publication (1961). Paper, 176 pages. Price, $1.50, United States currency, postage extra.